THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· MARCH · 1916 ·

SPRING MEETING, NEW ORLEANS, APRIL 11-14

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTENTS

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FEATURES OF THE SPRING MEETING

Stopover at Birmingham, Monday, April 10, en route to New Orleans, to be the guests of the Birmingham Section.

Opening Session at New Orleans on "Industrial Preparedness," with Paper by Spencer Miller, member of the Council, and of the U. S. Naval Consulting Board. This paper will be distributed to the entire membership, and a general discussion is solicited.

Address by W. B. Thompson, Commissioner of Public Utilities of the City of New Orleans.

Session on Engineering Problems of the South with papers on Multiple Evaporators, Low-lift Pumping Plants in the Gulf Coast Country, and Mechanical Equipment used in the Port of New Orleans.

Sessions with papers on Measurement of Flow of Fluids, and with miscellaneous papers on Dynamic Balance of Machine Parts, Center Crank Shafts of Gas Engines, Transmission of Heat, Fuels, Etc.

Excursion on the Mississippi River with an inspection of the harbor facilities and the new cotton warehouses.

Social entertainment on Thursday afternoon of the convention, and reception and dance in the evening.

Additional excursions on Saturday for those remaining in the city.

TRANSPORTATION

Official train from New York leaves Saturday, April 8, 3:34 p. m. via P. R. R. Official train from Chicago leaves Saturday, April 8, 11:45 p. m. via Big Four; and leaves Cincinnati Sunday, 8 a. m. via Queen & Crescent. Provision has been made for both trains so stop over at Birmingham on Monday.

For those who prefer to go by boat, the Southern Pacific Company offers accommodations on their steamer Proteus, which leaves New York at 12 o'clock noon on Wednesday, April 5.

No definite arrangements have been made for the return trip. A boat leaves New Orleans for New York on Saturday, April 15, at 10 a. m., due to arrive in New York on Thursday, April 20, at 7 a. m.

Full information about reservations, rates, etc., are given on page 235 of this number of The Journal.

Let every member who can do so attend this meeting, which will be unique and give an unusual opportunity for a glimpse of the South when at its best, and for the enjoyment of good fellowship and southern hospitality.

COMING MEETINGS OF THE SOCIETY

March 1, *Buffalo, N. Y.* Subject: Problems of the Consulting Engineer, by Dr. T. Kennard Thomson, Mem. Am. Soc. M. E.

March 1, *St. Louis, Mo.* Subject: The Collection and Disposal of City Refuse, by Hiram Phillips.

March 9, *Minnesota, Minn.* Subject: Unaflow Engines, by Herman F. Mueller, Mem. Am. Soc. M. E., and Chief Engineer of the Washburn-Crosby Company.

March 14, *New York, N. Y.* Joint meeting with the Illuminating Engineering Society. Subject: The Illuminating Engineering Society's Factory Lighting Code. The subject will be introduced by C. E. Clewell. Discussion from the standpoint of a mechanical engineer will be offered by L. P. Alford, Mem. Am. Soc. of M. E. The meeting will be preceded by an informal dinner at McDonald's at 6.30 p. m.

March 15, *Buffalo, N. Y.* Subject: History of Pumping Machinery, by Prof. A. M. Greene, Jr., Mem. Am. Soc. M. E., Prof. Mech. Engrg. Dept., Rensselaer Polytechnic Institute Troy, N. Y.

March 15, *St. Louis, Mo.* Major Willing of the U. S. Engineers will continue his course on Military Engineering.

March 16, *St. Louis, Mo.* This will be a special meeting in the form of a Ladies' Night.

March 17, *Chicago, Ill.* Subject: Development of the Crude Oil Engine, by S. B. Daugherty, Mem. Am. Soc. M. E., and Chief Engineer, Snow Steam Pump Works, Buffalo, N. Y.

March 18, *Cincinnati, O.* A joint meeting with the Engineers' Club of Cincinnati, at 25 East Eighth St. A more detailed announcement appears in the Society Affairs Section of this issue of The Journal.

March 29, *Buffalo, N. Y.* Subject: The Engineering Arm of Our Army, by Major Frazier.

April 5, *New Haven, Conn.* This will be a joint meeting with the Electrical, Civil, and Mining Engineering Societies. The meeting will take place at the Mason Laboratories, Sheffield Scientific School. Dinner at Yale Dining Club, 6 p. m. Evening session, 7 p. m., illustrated address by Samuel Insull, president of the Commonwealth Edison Co., Chicago, Ill., on The Progress of Economic Power Generation and Distribution.

April 10, *Philadelphia, Pa.* A joint meeting with the American Institute of Electrical Engineers. Subject: The Possibilities of Some Prime Movers Now Under Development, including Diesel engines, unaflow engines, locomobiles, and steam-gas units.

April 25, *Philadelphia, Pa.* The section will be addressed by Dr. D. S. Jacobus.

May 23, *Philadelphia, Pa.* Subject: Naval Engineering, or a kindred subject, by a representative of the Department of Steam Engineering of the Navy.

THE SPRING MEETING

April 11–14, *New Orleans, La.* Spring Meeting of The American Society of Mechanical Engineers. Headquarters, Hotel Grunewald. Full details concerning the transportation arrangements, hotel accommodations and attractions and the tentative program are given in the announcement of the meeting appearing elsewhere in this issue.

ANNUAL MEETING PAPERS

In this issue is continued the publication of abstracts of the papers given at the 36th Annual Meeting of the Society, held in New York, December 7 to 10, 1915, including the papers of the Textile Session, the Junior Prize paper for 1915, and papers contributed by the Research Committee and the Sub-Committee on Railroads. The three Textile Session papers follow.

HEATING BY FORCED CIRCULATION OF HOT WATER IN TEXTILE MILLS

BY ALBERT GREENE DUNCAN, BOSTON, MASS.

Member of the Society

SINCE the days of the old coal stove, three methods of heating textile mills have been in use: *First,* direct circulation of live or exhaust steam at low pressure; *second,* fan or indirect hot air system, using either live or exhaust steam in heating coils arranged in a central battery to heat the air; and *third,* use of hot water through direct heating surface in the various rooms, heating the water with either live or exhaust steam in closed heaters. This paper treats of the last method, which, with the widely distributed areas encountered in large textile mills, involves forced circulation of the hot water. It describes the manner of handling the problem of properly heating the widely separated units of the textile mills[1] shown in Fig. 1.

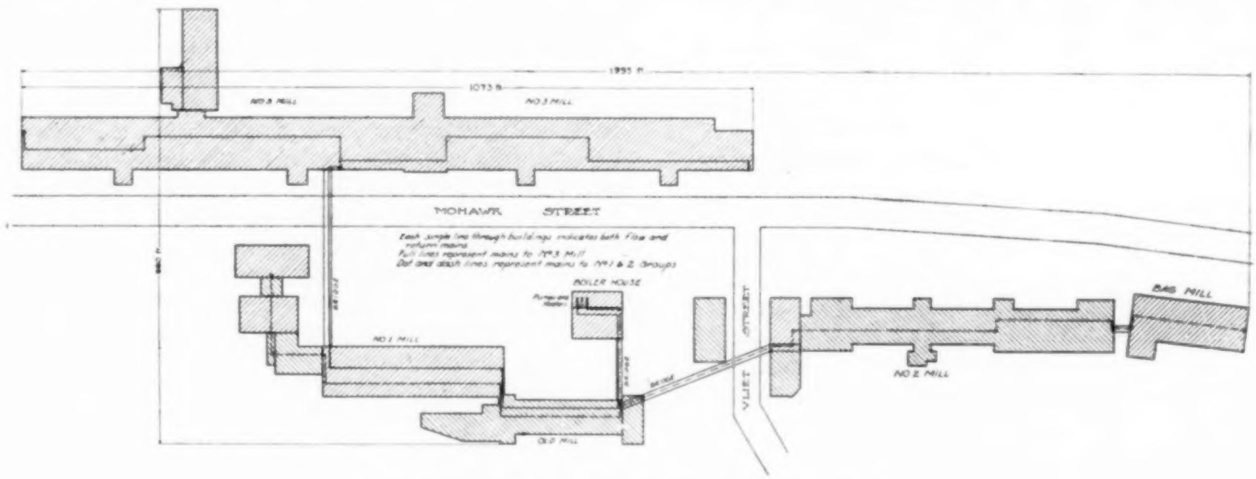

Fig. 1 Plan of Harmony Mills, Cohoes, N. Y.

A system of forced circulation of hot water was decided upon for three reasons: *a* The mills are primarily driven by water power, and the auxiliary steam plant which is in daily operation to carry about 20 per cent of the mill load, reaching a maximum of 50 per cent in times of low water, is located at a central point, the distribution of power being by electricity. *b* The central plant arrangement necessitated the carrying of heat over long distances. *c* As certain of the mills were located below the level of the power plant, a gravity system of return, either of hot water or steam, was impracticable.

The mills consist of seven buildings, varying in size from 40 by 100 to 1073 by 76 ft., and an office building; they contain 825,434 sq. ft. of floor surface and have a cubic content of 10,354,000 cu. ft. They present a somewhat typical condition in cotton mills, where buildings have been built of various types over a period of many years. The mills under consideration still use a building of three stories put up in 1837, and they occupy subsequent buildings, including their largest mill, consisting of five stories with basement, built in 1876.

The heating system was divided into two sections for convenience of regulation. The general direction of the mills was north and south, and the east side of the longer mill was on the top of a bluff 80 ft. above the river and exposed to extremely high winds. The mills being located in a northern latitude, where atmospheric temperatures of 20 deg. fahr. below zero are not uncommon, the question of different exposures of various portions of the plant was a special problem. Further than this, the plant naturally divided itself by its configuration into two manufacturing groups approximately equal in area; and consideration was given to the possibility of shutting down either of these groups and running the other at full capacity.

It was early determined that the regulation of the heat in the various departments should not be left to the individual overseers, but should be placed under the charge of the engineer in the power house, long distance reading thermometers being installed so that the temperature in different portions of the plant could be read there. By this method, the two primary factors of heat control, namely, the temperature of the water and the speed of its circulation, could be accurately regulated in accordance with outside temperature.

While there was no engineering objection to solving the problem by any one of the modern systems of direct steam heating, it was felt that the ability to control the temperature of water from a range of 100 to 240 deg. fahr. gave a flexibility to the system impossible of attainment in any other way. Practically stated, a steam system will operate economically only at full load, while a forced circulation of hot water can be readily regulated to meet all manufacturing and

[1] Harmony Mills, Cohoes, N. Y.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December, 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

weather conditions, and will maintain its efficiency at any degree of temperature.

The method of determining the amount of radiating surface required in various departments for a forced circulation system of hot water does not differ materially from the well-known methods employed in determining the heating surface of the number of heat units required for any other method of heating. Well-known factors were used in the installation described, and those in Table 1 are submitted as a basis for future determinations, bearing in mind that many modifying conditions apply which must be decided for each individual case.

The difference in temperature figured in the case under consideration was 70 deg. and the heat as that required to heat the mills to 70 deg. in zero weather with temperature of water 212 deg. For temperatures below zero, it was considered that the ability to heat water to 240 deg. and the heat given off by mill machinery in operation were ample margins of safety.

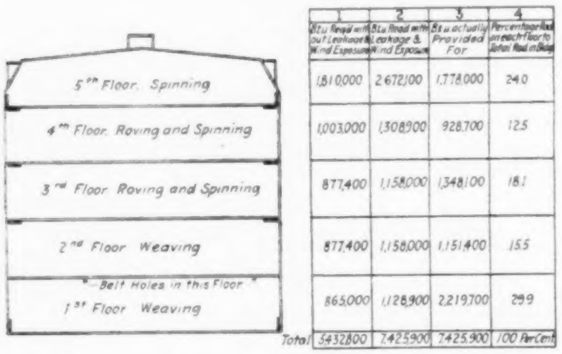

Fig. 2 Section of Mill Unit, and Proportioning of Heating Coils

TABLE 1 HEAT LOSS IN B.T.U. PER HR. PER SQ. FT. OF EXPOSED OUTSIDE SURFACE OF BUILDING FOR 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN INSIDE AND OUTSIDE AIR

Medium	Heat loss B.t.u.
8 in. solid brick wall	0.40
12 in. solid brick wall	0.31
16 in. solid brick wall	0.26
20 in. solid brick wall	0.23
24 in. solid brick wall	0.21
28 in. solid brick wall	0.19
Single window	1.00
Double window	0.50
Slate on tight wood roof	0.30
Standard mill roof 2½ in. plank T. and G.	0.18

The engineer will find plenty of opportunity for the exercise of his judgment in determining the percentage loss of heat to allow for leakage, window exposure, roof exposure, and other factors depending in each case upon the location of the individual building, and many other problems arise from the character of cotton mill operation.

In comparing the cost of a forced circulation hot water system with that of a good exhaust steam system, it may be said that with the exception of the additional cost of the pumping plant required by the former, the cost of installation of either is about the same. The cost of maintenance of the hot water system is believed to be much the lower by virtue of gradual rather than sudden changes of temperature of radiating surface and absence of water hammer.

The amount of radiation in the case at point was also calculated on the basis that the system would be adequate to heat up the mill following a shutdown of several days at zero temperature. On this account, no allowance was made for the well known fact that cotton machinery gives off a great deal of heat during operation. Consequently, the theoretical water temperature necessary to heat the mills was found to be many degrees too high during ordinary running conditions.

Fig. 2, which refers to one of the largest of the mill units, will make clear the proportioning of heating coils. The departments in this five story mill are shown in transverse section, together with the location of the heating coils on the side walls or ceilings. In this building there are about 1500 belt openings between the first and second floors.

Experience with the system later showed that more coils were placed upon the top floor and fewer upon the lower floor than were actually needed, this being due to belt openings mentioned and to the natural effect of heat leaking up through elevator shafts and other passages to the top floor of the mill, which also contained the spinning machinery, the kind of cotton machinery producing the most heat.

The heart of a forced circulation hot water system is the pumping plant. The pumping layout in these mills is shown in Fig. 3. The essentials of each unit are a closed heater, of the feedwater type, and a pump. Two pumps are used normally, one for each section of the mills. Each is connected to its own heater and is so arranged that in case of breakdown the third pump or heater shown can be used interchangeably with either of the two sections of the system. As to the type of heater, one with a short coil is preferable, to be run with the steam inside the coils surrounded by the water in the shell; this is an essential feature of the system, as the heater coil must be so proportioned as to clear itself readily of the water of condensation, which, at times of starting-up especially, is large in volume.

The heaters for this installation were of extra large capacity and adapted to use exhaust steam to heat the circulating water in any but the most extreme weather, when live steam is used. Their strength, however, was proportioned to receiving steam at full boiler pressure of 180 lb., so that in case of an accident to a valve when using live steam no danger could arise from explosion.

The three heaters were installed in connection with a boiler feedwater heater of the same size; and by a proper arrangement of valves, a greater or less amount of the exhaust steam furnished by the pumping plant and auxiliaries of the station could be used in the circulating water heaters or the feedwater heater as was required. The temperature of the circulating water could thus be maintained at any desired value.

Whether the heaters were using live or exhaust steam, the drips were collected in an open heater to which the make-up water of the boiler plant was added and thus were pumped back through the closed feedwater heater to the boilers.

In the present instance, the heating plant was installed in a station used only as an auxiliary unit, and a large amount of exhaust steam from auxiliaries was not available at all times, the main steam turbine being run condensing under high vacuum. For this reason steam driven pumps were installed, and it was found in practice that, except in extreme weather, they furnished sufficient steam to heat properly the circulating water. As the returns from the heaters were immediately delivered to the boilers, very little loss occurred in the transference of heat to the circulating water.

It can be readily seen that, in cases where a power station is used as a primary source of power, where large amounts of steam are used for service pumps or other purposes, an electrically driven or other form of power driven pump might prove most desirable. But it is the author's opinion that, unless the power plant in question operates on a twenty-four hour basis, a method of pumping by steam for a portion of each day should be installed, as it is the universal experience of textile mills that the larger proportion of the heat required during the twenty-four hour day must be supplied when the mill is not running. With the exception of a few departments, such as weaving, in any but the most extreme weather the heat engendered by the machinery is sufficient to keep the rooms at working temperature after 8 or 9 A. M.

As the system centers round the pumping plant, this was necessarily installed at an additional cost over what would be required for a system of direct steam heating, but the advantages of centralized control and steady and uniform temperatures more than offset the additional cost entailed. In the example under consideration, the pumping plant cost 29 per cent of that of the total system.

To obtain records showing the result of the system in actual service, the steam pipe supplying the turbine pumps, from which also the live steam was taken for the heaters in case of need, was furnished with a steam meter and, as a check, all other lines in the power plant leading to the main turbine, for mill uses and other purposes, were also metered. The total result was checked by a venturi meter on the feedwater side, and over a period of years the sum of these metered results checked within approximately 5 per cent, an amount which could be easily accounted for by boiler blow-offs, leakage, emptying of boilers, and other minor losses. Another meter was placed in the branch line feeding the circulating pumps alone, so that by subtracting the amount of steam required to drive the pumps, the steam going direct to the heaters could be accurately determined. A third meter in connection with the heating system was installed in the exhaust pipe as a check upon both the amount and the direction of flow of steam, as to whether or not the heaters were receiving exhaust steam from power plant auxiliaries, or whether exhause from the circulating pumps was being put into the feedwater heater supplying the boilers. Furthermore, two other flow meters measured all the water circulating through each of the two parts of the system, and these two main pipe lines were equipped with recording thermometers, giving the temperature of flow and return in each.

A summary of the records for the heating season 1914-15, is given in Table 2. The figures giving the average boiler horsepower for twenty-four hours are significant, and the author believes that no such result has ever before been accomplished in a textile mill of this size. Previous experience in other mills of about half the size of the one under consideration, heated by a combination system of direct steam and indirect hot air, gave results expressed in boiler horsepower of approximately twice the horsepower required in proportion to the size of the respective mills.

After the operation of the system had become thoroughly standardized, a marked saving in temperature of water and consequently in coal was effected. This result was accomplished after careful study of the amount of heat given off by manufacturing and machinery, attention to double windows over 80 per cent of the mill, elimination of draughts through stairways and elevator shafts, and any other conditions which prevented the system working at its best efficiency. This proves the chief claim that centralized control of heating in textile mills is the method for the most efficient results.

Fig. 4 shows a plot of the total steam consumption per day with different outside temperatures during all full working days when the system was in operation during the past $2\frac{1}{2}$ years, Mondays and the days following holidays excluded. It is noted that 500 boiler h.p. is required to heat the mills in zero weather. No heat whatever is required when the outside

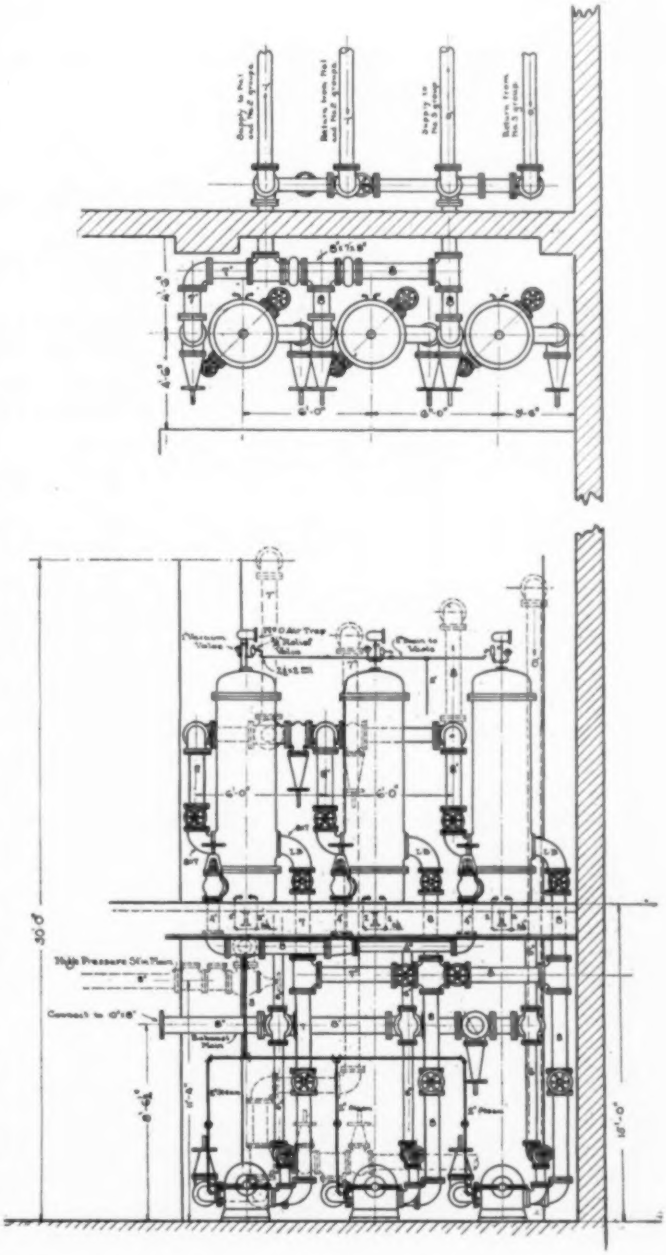

FIG. 3 HEATING SYSTEM PUMPING PLANT

temperature is above 50 to 55 deg., yet a temperature of 75 deg. is maintained throughout the mills. It must be remembered that about 7000 h.p. is used to drive the machinery; all this power is dissipated in heat from the spinning frames and other machinery, and its total heat equivalent is about 180,000,000 B.t.u. per 10-hr. day, or substantially 180,000 lb. of steam. Therefore, if this heat equivalent is added to that supplied to the heating system, we find the upper dotted

line extended to the base line would indicate no heat required with an outside temperature of 74 deg. fahr., which is substantially the average mill temperature maintained.

Fig. 5 gives a plot of heat supplied to the mills during Sundays and holidays during the past 2½ years when the system was in service. It was not the intention to maintain full working temperature of the mills when they were not running and a room temperature drop of 5 to 10 deg. usually took place, which was made up on the day following; therefore, the amount of heat on these days was less than that required to maintain a uniform temperature and that supplied on Mondays and the days following holidays was greater. An average line through the plotted points intersects the base line at an outside temperature of about 70 deg. and shows conclusively that more heat was supplied to the mills on Sundays and holidays than on full working days, even though the same temperature was not maintained.

The results from the operation of this system have demonstrated two facts: that the proper heating of textile mills is based on the one hand on a thorough understanding of the engineering problems involved, and on the other hand on a careful watching of losses of heat, which can be most readily accomplished by having the plant under centralized control.

Losses in heat arise from many causes. Our experience shows that the benefit of double windows offsets their cost many times, not only on the side of the mill exposed to prevailing winds but on all sides; in the case in question 80 per cent of the mill windows are double windows. Openings from the heated rooms to entry ways and elevator shafts are a constant cause of loss, especially at night, and during the first years of this system constant vigilance was necessary to impress upon night watchmen the importance of keeping all such openings closed. Non-enforcement of this regulation means that all the heat of the mill becomes centered in the upper story, where it is lost by the opening of windows, made necessary to keep the room at a working temperature. If study and proper regulation is made along the above indcated lines, except in extreme weather, heating can be confined in the daytime to the lower floors of the mill, to the weaving and carding departments, and to portions of the mill where very little machinery is in operation.

Certain other general subjects naturally fall within the

TABLE 2 OPERATION OF HARMONY MILLS HEATING SYSTEM 1914–1915

Week Ending	Average Outside Temperature Deg. Fahr.	Total Steam to Pumps and Heaters Thousand Lb.	Average Boiler H.p. Equivalent 24 Hr.	Total Heat in Steam Million B.t.u.	No. 1 Group of Mills					No. 3 Mill				
					Per Cent Time System in Service	Total Pumpage Million Lb. Water	Temperature Water Flow Deg. Fahr.	Temperature Drop in Deg. Fahr.	Mill Temperature Deg. Fahr.	Per Cent Time System in Service	Total Pumpage Million Lb. Water	Temperature Water Flow Deg. F.	Temperature Drop in Return Deg. F.	Mill Temperature Deg. Fahr.
Nov. 7...	49	242	43	240	27	20.2	117	7.2	73	18	15.3	108	5.8	75
14...	39	569	100	563	58	43.3	125	10.6	72	43	39.7	111	7.8	74
21...	33	961	170	952	78	63.1	136	13.1	73	71	57.1	117	8.8	73
28...	32	1,333	236	1,320	97	72.0	150	26.4	74	89	70.5	128	11.8	77
4 weeks...	38	3,105	137	3,075	65	198.6	132	....	73	55	182.6	116	....	75
Dec. 5...	41	638	113	632	76	49.4	137	23.0	74	66	43.1	110	5.3	80
12...	31	1,203	212	1,191	96	69.4	153	28.1	74	86	63.1	126	12.7	80
19...	24	1,667	294	1,650	100	70.7	173	27.8	76	95	73.9	127	15.1	77
26...	16	1,972	348	1,952	100	68.4	173	32.7	73	99	75.6	142	18.8	77
Jan. 2...	20	2,379	419	2,355	100	74.0	169	14.2	75	100	85.5	157	15.5	78
5 weeks...	28	7,859	277	7,780	94	331.9	161	....	74	89	341.2	132	....	78
Jan. 9...	27	1,623	286	1,607	88	64.8	154	11.4	75	87	69.2	143	10.7	77
16...	31	1,323	234	1,310	87	63.1	149	9.5	73	83	65.8	139	7.0	81
23...	32	1,103	194	1,094	73	51.5	153	11.2	75	67	53.1	136	6.7	78
30...	23	1,424	252	1,410	84	55.3	155	11.1	74	81	60.7	146	10.2	78
4 weeks...	28	5,473	241	5,421	83	234.7	153	....	74	80	248.8	141	....	79
Feb. 6...	20	1,876	331	1,857	87	57.3	160	11.4	76	82	60.7	152	11.3	83
13...	26	1,399	246	1,385	95	58.4	146	10.7	74	91	65.1	131	7.9	77
20...	32	1,202	212	1,190	83	47.2	148	11.2	76	74	53.3	134	10.0	82
27...	36	750	132	743	63	35.1	128	10.2	76	48	34.0	124	9.6	84
4 weeks...	29	5,227	230	5,175	81	198.0	146	....	75	74	213.1	135	....	82
Mar. 6...	25	1,529	270	1,514	92	52.9	152	13.0	75	79	63.4	133	8.4	80
13...	33	972	171	962	81	50.3	138	11.1	73	68	52.8	126	8.6	78
20...	35	1,066	188	1,055	93	57.4	147	10.4	75	64	43.1	125	9.6	80
27...	38	917	161	908	77	44.8	145	9.8	71	61	46.1	125	8.0	80
Apr. 3...	34	1,082	191	1,073	90	55.1	144	9.3	....	65	50.3	132	8.3	81
5 weeks...	35	5,566	196	5,512	87	260.5	145	....	74	67	255.7	128	....	80
Apr. 10...	48	422	74	418	41	25.1	141	9.4	....	24	17.3	121	5.6	....
17...	50	275	48	272	28	15.4	141	10.3	....	24	17.5	121	6.0	....
24...	56	95	17	94	10	6.5	122	11.0	....	5	2.7	102	8.6	....
3 weeks...	51	795	46	784	29	47.0	135	....	....	21	37.5	115	....	....
25 weeks..	35	28,025	198	27,747	73	1,270.7	145	....	74	64	1,278.9	128	....	79

limits of the above discussion. The relative merits of heating circulating water by live steam and exhaust is a matter to be decided entirely by the individual plant, as already indicated, and is based upon the conditions of the power plant operation and the available supply of exhaust steam. Where the amount of steam required for heating or other purposes is a small percentage of the amount required for power, it is not good judgment, in the author's opinion, to interfere with the highest possible efficiency of power production by the use of a small portion of the exhaust steam from the main power unit for heating purposes, and the question involved in that can usually simmer down to a matter of figures.

Offices or other rooms which require more heat or heat at different times of the day than is required in the mills and which do not share in receiving heat from manufacturing and machinery, must be separately provided for. These, however, represent usually but a small percentage of the total heat required that the general problem of mill heating is not affected by them.

In the mill in question, the office building is a detached structure, and during the first year of operation it is safe to say a large amount of heat was wasted by having this connected to the main mill system, as heat was required in offices on mild days when none should have been used in the mills. This difficulty was overcome by installing a siphon system of heating and circulating the water in this building by a special form of ejector or steam siphon which could be operated or closed off entirely independent of the mill system.

In the installation described another method of running circulation coils would have been preferable to the one used.

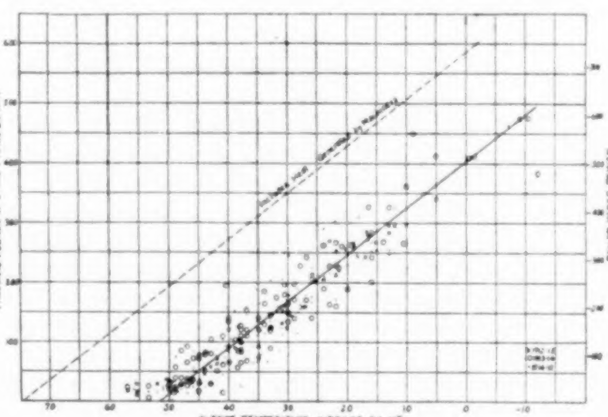

Fig. 4 Steam Consumption Per Day

The method used was the standard one, running the supply mains to the top floor of the respective mills and then, after distribution through the coils on this floor, returning the water through return drops to the return mains placed in the bottom story; in other words, the distribution was in a vertical direction. Although not affecting the efficiency of the heating system, a method of circulating the water through each floor or department by itself, leading out of and returning to vertical risers and return mains is preferred in a cotton mill using different processes on each floor, as it enables the heat to be put on and taken off of each department by the operation of the fewest possible valves.

DISCUSSION

Charles H. Bigelow said he noted that live steam was used for heating hot water part of the time, and the location of the heater required that all the condensation should be returned to the boilers through the feed pumps, which caused an extra expense, which could have been avoided if a closed heater was located in the upper part of the boiler house at a sufficient distance above the water line of the boilers, so that the condensed steam would return into the boiler by gravity, which would eliminate the expense of handling that steam, and thus make a further saving in the operation. As the upper floors of the mill would be above the location of this heater the pumps for handling the hot water could be located on the boiler room floor and would not have any extra work to do in handling the circulating hot water on account of the heater being elevated. This should be the most economical method

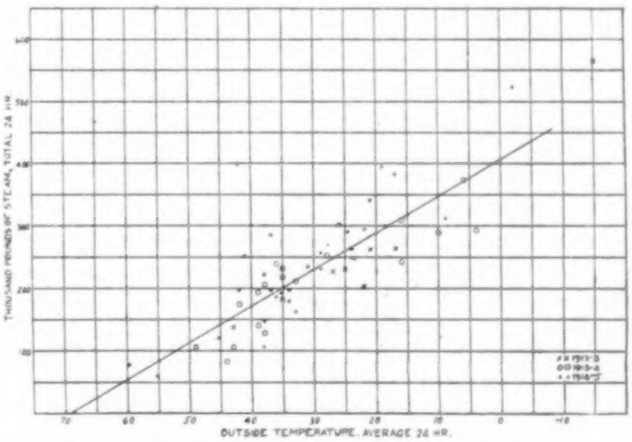

Fig. 5 Heat Supplied Sundays and Holidays

of heating the hot water as the steam would give up its latent heat of vaporization and return to the boiler without any work being done on it. In fact it would probably be more economical than trying to use exhaust steam part of the time, for as Mr. Duncan states, and as the speaker himself has noted considerable of the heating is required when no exhaust steam is available.

In a case of one large mill a hot water system was installed with the intention of heating the water by means of steam bled from a turbine. A reducing valve was also provided for use when the turbine was shut down. The condensation had to be returned to the boilers through pumps, which was a constant expense, and it worked out in practice that live steam was used a great deal more than the bled steam from the turbine, and that portion of the installation was not as economical as had been expected.

F. W. Parks said that a point the paper did not bring out was the comparison of coal cost.

There are very few industries that permit of a unit of heating cost comparison as well as does the textile industry. Mills running on the same grade of goods, and located in about the same climate, can be roughly compared in their heating costs on the basis of spindles, or looms, or production. In few other industries can such a comparison be made.

The cost of heating the mill which the paper refers to is just about half that of any other mill that he knew of, on anywhere near the same grade of goods, with the same necessary processes of manufacture. He said this statement was particularly true of the coal costs which he had of mills in New England that are doing their heating by exhaust steam or live steam, and that he based it on figures he had for Mr. Duncan's mills of the cost per spindle, the cost per square foot, the cost per cubic foot, and the cost per loom.

A. F. ERNST asked whether the heating and control of the atmosphere in the mill is automatic, or whether it is left to the operating engineer. He asked also whether there is any attempt made to control the humidity of the mill, and if so, what is the means of humidifying.

THE AUTHOR. In answer to the question whether the heaters could not be placed on top of the boilers, fed with live steam and the drips returned to the boilers by gravity, I would say that this plan was considered and in fact has been adopted by the author in a previous installation in a smaller plant. In the present case, however, it was desired to arrange the heaters so that they could be readily operated either by live or exhaust steam without the use of traps or other complicated devices.

The power plant in this mill is a steam turbine and it was considered at the outset whether exhaust steam should not be bled from the main turbine exhaust for heating. The knowledge, however, that most of the heating would be done when the turbine was not in operation, decided against this plan.

The power plant has steam driven auxiliaries and in addition to the usual boiler feed pumps and the circulating pumps for the heating system, a combination motor and steam driven unit, consisting of centrifugal injection and air pumps for the main turbine condenser. We had consequently a large and varied amount of exhaust steam from auxiliaries and never attempted to use steam from the main unit. By dividing the load of about 150 horsepower between the motor and steam turbine driving the condenser pumps, the amount of exhaust steam can be accurately limited to the amount that the feed water heaters and the heaters of the heating system can condense without excessive back pressure. We can also easily adjust the amount of steam going to the feedwater heater or the heaters of the heating system. These heaters were also placed high up in the plant and drained by gravity to an open heater to which make-up water was added and the feed pumps located lower than this open heater, took their suction from it under a head. Another reason we did not put the heater on top of the boilers and limit their use to live steam, was because we found during zero weather our water power was so irregular that calls on the steam plant were made to its full capacity; consequently, at such a time our auxiliaries are running full blast and have plenty of exhaust steam which can be utilized in the heating system and the water condensation easily pumped back to the boilers through the arrangement of an open heater as mentioned before.

In regard to the question by Mr. Ernst, the control of the heating in this mill is not automatic, but is done by the engineer in the power plant using a chart showing the temperature of water to be carried in relation to outside temperature. In times of very mild weather, additional regulation can be secured by running the circulating pumps at reduced speed. We have found this method amply able to take care of the varying requirements for heat at different times during the day in the different rooms of a textile mill without the expense and complication involved in automatic control of either water temperature or flow. The humidity control is left in the hands of the foreman of the different departments and is non-automatic.

The United States Bureau of Standards has made an investigation of the causes of failure and deterioration of fusible tin boiler plugs in service. The report of this investigation is embodied in Technologic Paper No. 53, issued by the Bureau.

RELATIVE VALUE OF PRIVATE AND PURCHASED ELECTRIC POWER FOR TEXTILE MILLS

BY F. W. REYNOLDS AND DAN ADAMS, BOSTON, MASS.

Members of the Society

THE rivalry between the isolated plant and the central station has called forth many valuable and interesting papers, usually prepared by those most vitally interested either in the isolated plant or the central station. It is perhaps safe to state that it is difficult to prove the general proposition entirely in favor of one side or the other. Each case is a problem to be decided on its own merits, and the correct solution can be assured only by a correct evaluation of all the various technical and financial factors involved.

RELATIVE COST OF PRIVATE AND PURCHASED POWER

Figs. 1 and 2 give the cost of purchased power for ordinary textile mill conditions for any load up to 2000 kw. These curves are plotted from the published schedules of public service corporations, one in New England and one in the Middle West. While rates as good as these cannot be obtained in all localities, still these are actual and representative rates. For comparison, the cost of private power has been plotted, using in each case the price of coal obtainable in the district served. The cost is for power delivered at the point of distribution at 550 volts in all cases. No provision is made for use of steam other than for power, and where such use is considerable, the relative cost of private power may be much lower than given. While the cost of purchased power given is actual, the cost of private power is theoretical, and is not intended to give more than an approximate and general comparison, but is based on known actual conditions.

In an actual private plant the power cost very often exceeds that given. The investment as stated is too low to cover any reserve or relay capacity, and therefore the reliability must be considered somewhat inferior to that of those central stations which were used for this comparison. Also, the investment will not take care of any disadvantageous conditions, such as expensive foundations or difficulty in obtaining condensing water; and no cost items are included for land or for coal in storage. All of these items are too indefinite to be included in a general cost estimate, but are always encountered to some extent. The operating costs assumed, while no better than should be obtained, are really somewhat lower than the average. Nothing has been included for supervision other than the actual power plant labor, but this supervision is usually a legitimate item of expense.

A textile mill load is properly considered somewhat more favorable than the average industrial load on account of its very steady demand for power, not only throughout the working period of each day, but also throughout the year and over a period of years. For this reason, special power rates can be obtained by textile mills in some localities, notably in the South, and to some extent in New England. Under these special rates, power usually costs about 1⅛ cents per kw-hr. for demands from 1000 to 2000 kw. and about 1 cent above 2000 kw. Such rates leave little financial inducement for the mill to build its own power plant.

It will be seen that the curves, Figs. 1 and 2, are very nearly parallel. This means that the size of the demand has little

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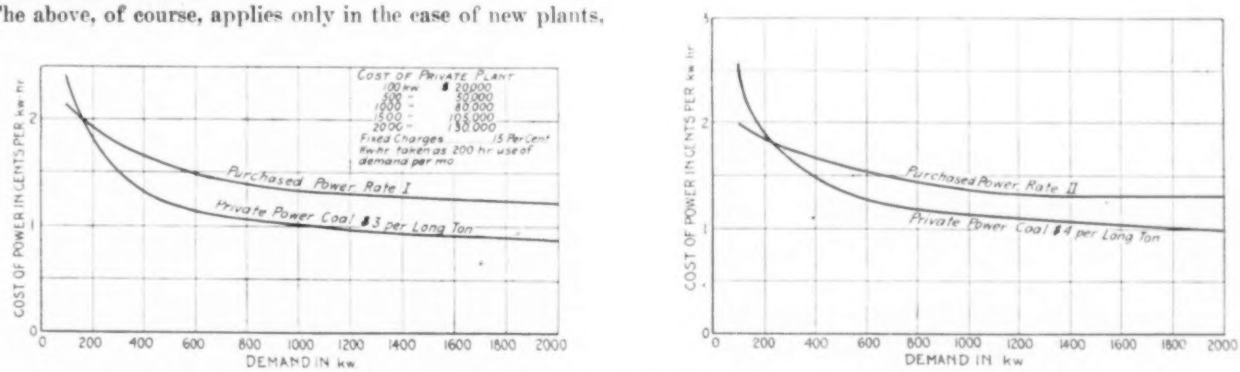
effect on the relative cost. The larger plants show a slightly larger proportional saving than the smaller ones, and the very small plants—under 200 kw.—cannot compete with the purchased power rates given.

Figs. 3 and 4 have been prepared from the same data as Figs. 1 and 2, to show the effect of load factor on the cost of power in the case of a 1000-kw. demand. It will be seen that the curves for private and purchased power costs follow the same general direction. It appears, then, that load factor also has little effect on the relative cost of power.

There is a striking similarity between the curves shown for private and purchased power, both when the variable is the size of the demand and when it is the load factor. The inference is that these power rates were devised to compete with isolated plants rather than from actual costs, or desired rates, of the central station power. This is entirely logical, being simply an application of the law of supply and demand. If it be true that the cost of central station power is determined by the cost of generating in isolated plants, then it will be unnecessary to discuss further the relative cost. It is improbable that the central station will sell cheaper than the average isolated plant cost, and if its rates are very much higher, it cannot sell much power.

The above, of course, applies only in the case of new plants, where power can be purchased without any sacrifice of existing investment, and where steam is needed only for power. Also, it must be remembered that the individual plant may depart widely from the average.

All that has preceded is a comparison of purchased and private power where the private plant is not yet built. But, in the case of a going plant, the purchase of power would save operating expense only, and would not wipe out fixed charges on investment already made. Fig. 5 shows the cost of private and purchased power, as in Fig. 1, but without including fixed charges. This, then, is a comparison between purchased power and a going plant under good working conditions. The difference in cost is so great that it appears improbable that central stations can cause existing plants to shut down unless in the case of important changes or additions, or the necessary renewal of considerable apparatus, or because of extremely poor operating economy.



FIGS. 1 AND 2 RELATIVE COST OF POWER FOR LOADS UP TO 2000 KW.

EFFECT OF USE OF STEAM ON COST OF POWER

Every textile mill uses some steam for heating and manufacturing. This factor is of great importance, and should always be weighed accurately in considering purchased power. In general, textile mills may be divided into two classes in this respect. The first contains those mills using only a relatively small amount of steam in manufacturing, and includes most silk and knitting mills and cotton and woolen mills not engaged in scouring, bleaching or finishing. Dye houses, finishing mills, print works, and textile mills which finish their product are included in the second class, and have a large but variable demand for steam in the process.

Slashing may be taken as typical of a small demand for manufacturing steam. Very often exhaust steam is used in this process. The pressure desired varies from 5 to 12 lb., which is a suitable pressure to bleed from an engine receiver or bleeder turbine. Only in rare cases would it be economical to run non-condensing apparatus to supply slashers on account of the high back pressure required and the relatively small demand. In the case of a bleeder turbine, the saving in live steam amounts to about 30 to 40 per cent of the steam bled. This saving is reduced by additional fixed charges on extra cost of turbine and exhaust piping, for a relatively small service, and, in a large plant with a long run of pipe, may be negative. For a rough figure, applicable to average conditions, the gross saving will be about $200 per year for each 1000 lb. per hour bled, with coal at $4.00 per ton. This figures out about $0.0001 per kw-hr. in the case of a large cotton mill, or about 1/50 of 1 per cent of the cost of production.

While there is no doubt that exhaust steam can be and is successfully used in slashers and similar machines, still live steam at reduced pressure has a tendency to reduce operating difficulties and increase production. When exhaust is used, there are apt to be occasional periods when results are not satisfactory, due to a temporary drop in pressure or excessive condensation or to adverse atmospheric conditions.

As regards steam for heating, there are two factors, often ignored, which militate against the use of exhaust in textile mills, especially in cotton and woolen mills. One is the large amount of heat liberated from the machinery during working hours and the second is the diversity in time between the use of power and of steam for heating.

In some cases, the machinery provides more than half of all the heat required in zero weather, and for much of the heating season no extra heat whatever is needed during working hours, except in the storehouse and basements.

In a weaving mill in northern Massachusetts, where the power used per cubic foot of space is much less than in a balanced mill, the heating system was actually in operation only 25 hours per week average during working hours during the heating season, or about ¼ of the entire yearly operating time of the mill. Of course, all heat used outside of working hours—nights and week ends—must be live steam. If exhaust is to be used the rest of the time, as a general rule, it is proper to count on a demand only about one-half of the maximum, since the machinery provides the remainder, and this quantity

probably will not be used more than 700 hr. per year. The only way to meet a demand for exhaust of this character with economy is by bleeding from an engine or turbine. In a cotton mill cited above, bleeding steam for heating would effect a saving amounting to $0.00005 per kw-hr., a little less than in the case of slashers. In knitting and silk mills, the saving will be relatively greater, but in warmer climates much less.

It appears, then, that the coal saving effected by using exhaust steam for heating and slashing is very small—smaller, in fact, than the unavoidable errors in estimating the total cost of power. There is, however, some further saving due to economy in investment. It is apparent from the foregoing that if steam for these demands is bled, the extra boiler capacity necessary to meet them is reduced approximately one-half. Also, it is cheaper to get this extra boiler capacity as part of a larger plant built for power generation than to provide it in a separate plant by itself as would be necessary if power were purchased.

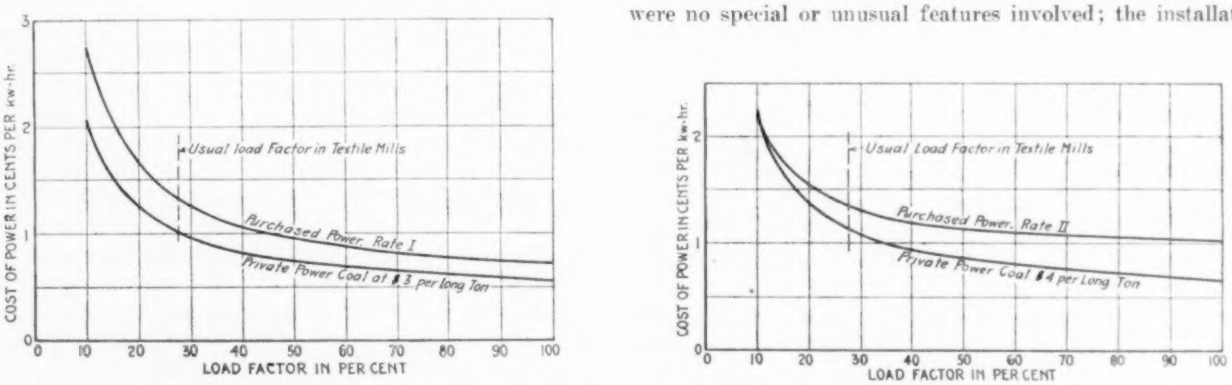
This matter was investigated in the case of a fairly large cotton mill. It was found that the complete power plant would cost $65.00 per kw., but if the cost of an independent steam plant for heating and slashing were deducted, the cost would have come out about $58 per kw., this latter being the figure used in comparison with purchased power.

While it is entirely unsafe to apply average figures to individual cases, it is desirable to form a clear conception of the relative importance of the various factors, and we may say that, in general, the entire fuel and investment saving due to the bleeding of steam for heating and slashing will range from $0.0005 to $0.0010 per kw-hr. A saving of this size cannot have a very important influence on a decision for or against purchased power. Nevertheless, the matter should always be considered.

A very different result is obtained in those mills having a large demand for steam for boiling water and drying cloth. In such cases, a large proportion of the prime mover exhaust may be utilized. In some cases, all power is produced in non-condensing apparatus, and all exhaust utilized, and manufactured power becomes then so cheap that no central station can compete. It is seldom, however, that a textile plant can utilize all of its exhaust all the time. This is because of diversity in time and amount between the use of steam and use of power. The importance of this can best be shown by citing an actual case.

Figs. 6 to 11 give curves showing the demand for steam in a worsted mill dye house for one week's operations. These curves are plotted from actual flow meter readings in exhaust main, which were taken every fifteen minutes. In this case the exhaust was provided by a non-condensing turbine. For comparison, the steam fed to the turbine was measured on one day and plotted. For the other days, the steam to turbine was averaged from the kilowatt-hour readings. The curves show how the demand for steam varies from hour to hour and day to day, and also lags behind the power load.

The demand for steam in a dye house is light early in the forenoon, but persists for two hours or more after the mill is shut down. The dye house does not run at all on Saturday mornings, which is a custom not uncommon. The result is a very large surplus of exhaust which must be wasted, and in spite of this, considerable live steam make-up is required, as shown by the curves. It is obvious that such conditions result in great inefficiency. Actually less coal would have been burned if a standard condensing turbine had been installed and live steam exclusively used in the dye house. The expected result of this installation was that power would be furnished as a by-product at a purely nominal cost. The actual result was that the power cost was considerably higher than in a plant having no use for steam in the process. This case is especially worthy of study because it is a typical balanced worsted mill of fairly large size doing its own dyeing; there were no special or unusual features involved; the installation was actually made, and the results as given were determined by careful tests.



FIGS. 3 AND 4 RELATIVE COST OF POWER FOR LOAD FACTORS 10 TO 100 PER CENT

The reasons and calculations leading to the installation of this non-condensing turbine are not known to the authors, but there is no reason to doubt that the installation promised to be very profitable. The total steam used in the dye house was considerably in excess of that to be supplied by the turbine, and it was apparently safe to assume that all exhaust would be utilized. With the turbine, there would be no trouble from oil, and the exhaust pressure was taken at 10 lb. to give good service.

The factors which made this attempt a failure were

a The diversity in time and variable demand for steam

b The deterioration of turbine which gradually increased its steam consumption

c It was found by experience that a few of the processes in which the use of exhaust steam was tried suffered either in quality or speed of production. For this reason the actual demand for exhaust probably was not as great as that estimated, although this difference was not very large.

It is evident that all of these factors may be encountered in any similar installation and must be allowed for in the estimates.

It is interesting to inquire if it would have been possible to make this installation efficient and still use exhaust steam. The demand is so variable that it is hardly probable that a non-condensing turbine could be satisfactory. It would be im-

possible to avoid surplus exhaust at times and live steam make-up at others. A bleeder turbine appears to meet the situation better, but is not without its difficulties. The required output of the turbine is about 1200 kw. The maximum amount that can be bled at that load from a 1200-kw. machine is about 12,000 lb. per hr., but the greatest demand for exhaust steam in the dye house is 50,000 lb. per hr. If the turbine has different characteristics, involving practically a 2400-kw. steam end, all the exhaust needed could be bled, but the turbine would run at half load economy. It would be better to use an intermediate size and bleed what steam is possible, supplying the dye house peaks with live steam make-up.

Table 1 gives the total steam used per week during the operating time of the mill for turbine and dye house for the operation as actually observed; as it would have been if guaranteed steam rate of turbine had been maintained; if a condensing turbine had been installed; and with a 1600-kw. bleeder turbine.

These figures show that the condensing turbine is cheaper to operate than the scheme installed, and is not much more expensive than any of the schemes. It is safe to state that the condensing turbine would have been the lowest of all in first

TABLE 1 STEAM USED FOR POWER AND MANUFACTURING

	High Pressure Steam to Turbine Lb. per Wk.*	High Pressure Steam Make-up in Dye Ho. Lb. per Wk.	Total High Pressure Steam Lb. per Wk.
Present operation, 1200 kw. non-cond. turbine	3,110,000	....	3,110,000
Same with guaranteed steam rate of turbine maintained	2,466,000	47,000	2,513,000
With 1200 kw. cond. turbine	1,120,000	1,580,000	2,700,000
With 1600 kw. bleeder turbine	2,294,000	273,000	2,567,000

* Includes turbine auxiliaries. Condenser driven by motor.

cost and the most satisfactory from the standpoint of dye house operation.

In this particular case, then, a large demand for steam in the process has little influence on the relative cost of private and purchased power. If power generation in a condensing turbine with live steam used in the process is as economical as the use of exhaust steam, the comparison previously made between purchased and private power where there is no demand for steam is approximately true in this case. There would be some investment saving in providing steam capacity for manufacturing as a part of a larger plant.

It is hardly possible to give general figures of any value to show the effect of large steam demands on the cost of power. In many cases, the factor is of less importance than has commonly been supposed. Nevertheless, it seems entirely improbable that purchased power can compete successfully in very many cases of this kind. The success of the private installation, however, depends very largely on the skill and thoroughness of the preliminary study of conditions, with special attention paid to the diversity factor and to the variations in demand.

RELIABILITY, DESIRABILITY, ETC.

In textile work, the reliability of power is usually of greater importance than its cost. This is because the cost of power is a very small item in the cost of manufacturing, whereas reliability affects the earning power of the whole mill at its foundation. It is rather difficult to collect satisfying statistics on power reliability by each method of supply. One cotton mill buying power reports interruptions totaling 45 min. in five years. In this case the transmission line was less than half a mile long. Reports from several central stations give total interruptions on the individual lines ranging from 12 min. to 4 hr. per year.

A hydroelectric company in the South, which sells to many mills, reports that interruptions of service to textile mills from all causes have averaged less than 2/5 of 1 per cent for the last nine years. Such records are doubtless better than the average. A large number of managers of representative mills in the South purchasing hydroelectric power state that they consider this more reliable than private steam power.

In most cases, purchased power is transmitted electrically by pole lines. Where these lines are short, well constructed and in duplicate, the reliability is very good. On the other hand, a single line many miles in length and fed at a long distance from the consumer is subject to interruptions and regulation troubles. It is fair to state, however, that great improvements have been made in the reliability of transmission.

The reliability of generation is usually better in a large central station than in an isolated plant, and this is especially

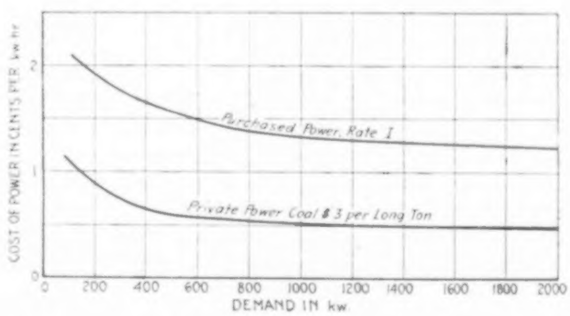


Fig. 5 Relative Cost of Power, without including Fixed Charges

true when a number of stations are tied to the same system.

In considering the purchase of power, reliability should be treated as a very important factor, and carefully investigated. If there is any serious question on this point, the private plant would be the wise decision in most cases.

Assuming that reliable power can be purchased at a cost approximating that of private power, it is not apparent that there are any attending disadvantages. There are, rather, many points in its favor. The saving of investment for a power plant often is considered important, especially when that money can be invested to better advantage in the manufacturing plant.

Specialization in manufacture of product only is worth something. A considerable part of the effort of the engineering department of a mill is devoted to keeping the power plant running efficiently. Where cost of power is only 2 or 3 per cent of the cost of manufacturing, the services of the engineering department would probably be of greater value to the mill if devoted solely to keeping the producing machines running efficiently.

In the case of a new development subject to future growth, the central station offers a perfectly flexible source of power.

When a radical change in existing conditions is introduced it is inevitable that there will be some wrong applications. Whenever the purchase of power proves undesirable, or too expensive, it is easy to give it up. The fact that so very few plants have gone back to private power after once purchasing

is pretty good evidence that purchased power really is desirable.

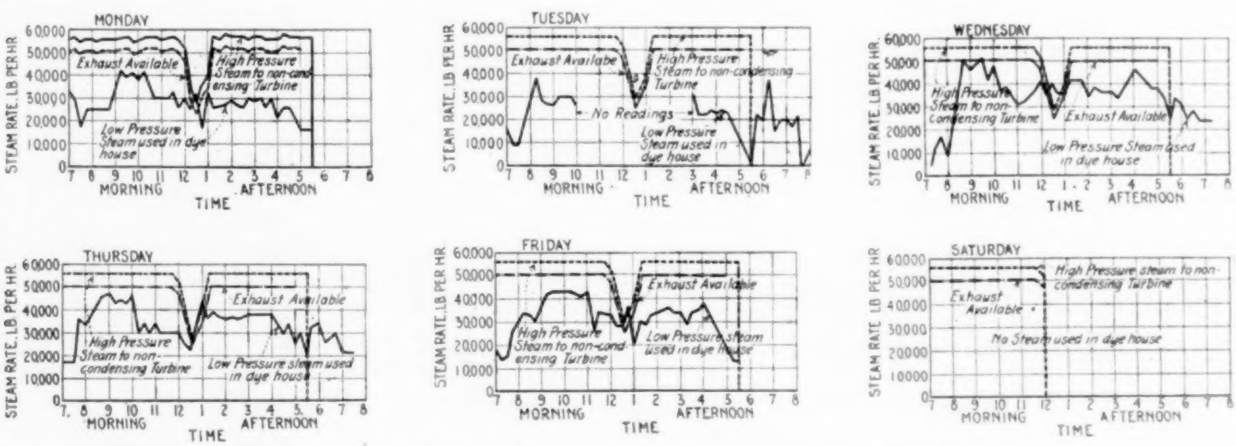
POWER CONTRACTS

Conditions governing the use of power in textile mills are such that power companies often offer them special rates at a flat price per horsepower-year or per kilowatt-hour, with a guaranteed minimum. Such a contract would be received more favorably by the average mill man than one based on demand and monthly use of demand with various discounts, even though the final results were identical.

TABLE 2 POWER PURCHASED FOR TEXTILE MILLS

From U. S. Census Report for 1910

Industry	Total h.p. Used	Total h.p. Purchased	Per Cent Purchased
Cotton goods, including small cotton wares	1,296,517	108,512	8.4
Hosiery and knit goods	103,709	13,286	12.8
Silk and silk goods including throwsters	97,947	10,354	10.6
Woolen, worsted and felt goods and wool hats	362,209	13,783	3.8
Total	1,860,382	145,935	7.8 Average
All Industries	18,675,376	1,749,031	9.4



Figs. 6 to 11 One Week's Steam Demand in Worsted Mill Dye House

Contracts for purchased power should be carefully studied in all detail before signing, as there are many technical features which are sometimes made to react to the disadvantage of the consumer. In general, power companies show a tendency to get the consumer's point of view and to make their contracts more simple and more liberal.

PURCHASED POWER IN THE TEXTILE INDUSTRY

The figures in Table 2 from the 1910 U. S. Census show the total and relative amounts of power purchased in the various textile industries, and also the total figures for all industries, for the year 1909.

It will be seen that the hosiery and silk industries purchase relatively more power than the average textile mill, and this might be attributed to the comparatively small demand for power in these mills. The small use in woolen mills is probably due to the generally large use of steam in this industry. Since these figures were compiled, the capacity of central stations has more than doubled. It will be interesting to observe from later census reports if the use of purchased power in the textile industry has increased proportionately.

DISCUSSION

Fred N. Bushnell (written). One notable feature of the paper stands out prominently, and that is the absence of any attempt to show the relative value between mechanical and electrical drives, which indicates that material progress has been made in the trend of thought and state of mind with which engineers, closely in touch with textile problems, now view the application of the electric motor to this class of work.

One of the greatest difficulties encountered in any attempt to show comparative costs, and one that nearly always places purchased power at a disadvantage, is the incomplete knowledge of all the facts entering into the cost of private plant manufacture, and the necessity of assuming economies which may or may not be realized in practice.

The authors frankly point out that in an actual private plant the power cost very often exceeds that given; that the investment as stated is too low to cover any reserve or relay capacity; that the investment will not take care of any disadvantageous conditions, such as expensive foundations or difficulty in obtaining condensing water, also that no cost items are included for land or for coal in storage, all of which must be taken into consideration in studying the curves.

On the other hand a price named for purchased power is a definite, unequivocal and positively known quantity about which there is and can be no question, and this fact should also be borne in mind in any attempt at comparison.

We have now reached a period of highly developed specialized knowledge in matters immediately affecting our principal activities, and a tendency has very naturally developed to eliminate all problems of minor importance, not directly connected with our principal article of manufacture.

The shoe manufacturer is seldom a tanner of the leather or a weaver of the cloth he uses, the toolmaker does not mine or produce the steel he needs, nor the miller the wheat he grinds, and the day is approaching when the textile mill will find no more reason for manufacturing its own power than it will for the study of the intricacies and uncertainties of agriculture in order to supply its raw cotton.

The authors are to be congratulated upon the evident fairness with which they discuss the subject.

John A. Stevens (written). Although this paper purports to be an unbiased comparison of isolated and central station electric power, it conveys the impression that the latter is preferable.

As the authors state, each case is a problem to be decided on its own merits, and the correct solution can be assured only by a correct evaluation of all the various technical and financial factors involved. Each is, in other words, strictly a technical and financial problem which requires careful study indicating economies brought about by a certain investment, of which the savings affected by the increased economies represent a certain earning. Sometimes the balance is in favor of isolated power and sometimes of central station power.

A proper comparison of the two systems of power must include the following items, which are very often slighted, misrepresented or omitted: To the price of purchased power must be added the fixed costs of all transforming equipment, including housing, transformation losses and cost of attendance; and if an existing plant is superseded, its fixed charges must also be included at full value.

The cost of isolated power should include every item associated with the power plant, that is light, heat and power and all thereto connected, due reduction being made for use of steam for heating and manufacturing purposes. The fixed charges on the investment, 12 per cent of its initial value being sufficient, should include heavy foundation waterways and coal handling apparatus along with the other plant equipment.

It should be brought out here that careful design of the private industrial plant is of prime importance if central station power is to be competed with. In numerous cases of industrial plants having been pronounced failures, more attention was paid toward making the plant attractive than economical.

The question of reliability has often been brought up. A prime mover is as reliable in an isolated plant as it is in a central station, and if the isolated plant possesses more than one unit, reliability is not a factor. The prime movers in a well run plant are the most reliable parts of the plant. The weakest part of a central station system is its distribution, and from this source the prospective purchaser of power will experience the most inconvenience.

The authors' examples of power costs clearly represent special cases in which, with study from different aspects, the favor might be swung back to isolated service. In the case of the dye house, for example, numerous factors are not considered. Low pressure steam requires piping much larger than does high pressure. A combination of a condensing and exhaust steam turbine will greatly help out the diversity of steam and power demand, and at the same time eliminate some of the losses in bleeder turbines.

One of the most important features not mentioned is an absolutely controllable supply of low pressure or stage exhaust steam at some predetermined pressure. That is to say, whether or not a low pressure system can be installed in a plant depends on the amount of low pressure steam to be used, the amount of power to be used and the cost of installation of the low pressure system, including the additional rates imposed on the steam plant by the low pressure system. A suggested method of approach is a complete analysis of light, heat and power in its every minute detail, including the land occupied by the equipment as against the purchased power, where practically no space would be absorbed by an isolated plant. Further, it is to be specifically recommended that in every case power be purchased in the form of energy, that is, on the basis of kilowatt-hours used.

R. J. S. PIGOTT. The authors conclude that for small power plants there is very little chance for the isolated plant to make good. In the small plant, the duties for the men operating it are small and cannot occupy their whole time. A low grade man is very frequently employed, and only works part of his time in the power plant, causing the reliability to suffer.

For a fair comparison between the isolated plant and the central station another point which must be known is whether or not proper reserve is carried in the former. The authors state that in few industrial plants is a proper reserve carried, and this has been my own experience. Enough engine or turbine power is put in to run the plant when all the machines are operating, but no spare units are carried. Such a plant is not in a position to be compared fairly with purchased power, because it is not as reliable as a central power station. If the central station carries a 20 or 25 per cent reserve, the isolated plant ought to carry that much, if the reliability is to be the same.

In the cotton industry there is stated to be very little chance for the use of exhaust steam, which seems extraordinary. It is possible that the temperature demand is such that live steam direct to the machines must be used, but it would appear well for mill owners to remodel their processes so as to use low pressure steam wherever possible in place of high pressure steam.

In the works where I am now engaged, nearly half the steam put through the turbines is employed either in the processes or for heating. The power plant has a capacity of 13,000 kw. In this particular plant, low pressure steam, 15 lb. gage, drawn from bleeder turbines, is supplied. Whatever steam is not required for pressures or heating in the main plant is passed on to the condensers, with the consequent benefit of comparatively high economy on whatever steam is not used in the bleeder system. The steam consumption would be very nearly doubled if we were to use high pressure steam drawn from the boilers, and condense all the steam sent through the turbines.

We have remodelled a number of our processes in order to make use of low pressure steam; the effect upon kw-hr. cost is very pronounced, as the power from bleeder turbines is produced at 75 to 90 per cent thermal efficiency. The case is analogous to that of steam auxiliaries exhausting into a feed water heater.

From an inspection of most of the industrial plants which make use of steam in processes, it would appear that not sufficient attention is given to the ability of the bleeder turbine to furnish steam at a very low cost; and for those who are interested in the question of private or purchased power for industrial works, it would be very advisable to give serious consideration to the remodelling of their processes and heating conditons, to make as much use as possible of bleeder turbines. The growth of sales of this type of turbine in the last two or three years indicates that the advantages of low pressure steam for industrial purposes are being realized.

F. J. BRYANT. This problem of exhaust steam came up when we enlarged the power plant of our cotton finishing works, where a large portion of the steam generated is used for drying. We considered the bleeder turbine very carefully and decided that it did not meet our needs.

We have at present a number of 5 to 10 h. p. "Twin-angle steam engines," which drive drying machines and serve a double purpose of speed regulator and reducing valve. The part of the machine which these engines control consists of a set of drying cylinders over which the cloth passes after it has been partly dried over steam coils. The steam in these cylinders, and the amount of steam in them, depends upon the weight of the goods which they are drying and the amount of moisture in them. As the engines discharge their exhaust into a header

which supplies the cylinders of several machines, very good economy is secured. If the pressure falls too low more is admitted by a reducing valve, and if it gets too high a safety valve lets it off. A turn of the throttle valve speeds up the work and lets more steam into the system. All drips and condensations are trapped to a hot well and then returned back to the boiler.

As we now have a surplus of low pressure steam, we are considering the substitution of an alternate current motor and variable speed transmission for one of the engines, and thus cut down the exhaust.

ARTHUR L. WILLISTON. In this paper the author has assumed that there are three objections to the isolated plant: first, the lack of opportunity to use the exhaust steam; second, lack of margin in the plant; and third, lack of reliability. These are serious shortcomings for any plant to have, but I think it is important that we should not associate them with any particular type of plant. I am sure that we all know central stations that have at least one of these defects; and in some instances all three may be present. It is also true that isolated plants may be so designed and operated as to have none of them. The point that seems to me to need special emphasis is the fact that the same high quality of skill and judgment that is usually bestowed upon the design of the central station is, as a rule, equally important for the isolated plant.

For example, there is not the slightest reason why the isolated plant should not have as large a margin as is needed. It surely is not necessary to go to a central station in order to get a wide margin. It may be obtained in any plant.

Likewise, it is not necessary to go to the central station to get reliability. In the isolated plants with which I have had experience for the past twenty-three years (which happen to have been plants in educational institutions) we have had as great a degree of reliability as we could reasonably expect to have from central stations. In the last plant, since it was started five years ago, we have had practically perfect reliability. A central station does not always give an absolute 100 per cent of reliability.

During the previous discussion it has been pointed out that in an isolated plant processes may often be remodeled so as to use exhaust steam in place of high pressure steam, and that when this is done there is distinct economy in favor of the isolated plant as compared with the price of power furnished from a central station. In educational plants there is little opportunity to use steam for special processes, but they do use large quantities of exhaust steam for heating.

Our shop and laboratory buildings at Wentworth Institute contain equipment not very different from that found in a great many manufacturing plants, and are, for illustration, in almost every way quite typical of the small plants in a great many industries. It is our experience that the exhaust steam used for heating alone consumes all, or very nearly all, the exhaust of our power plant, for six months in the year. There is during the other six months a certain amount of waste, but for one-half of the year the only cost of light and power is a small depreciation charge for the engine dynamo and the renewal of the lamps. A very distinct economy will usually be found in favor of the isolated plant wherever conditions approaching these can be found.

In a great many instances wrong conclusions have, I think, been drawn when making comparisons between isolated plants and central stations because persons have relied on data drawn from improperly designed isolated plants rather than from the results that would be obtained from well-designed isolated plants with thoroughly up-to-date equipment and with all opportunities for economy taken adavntage of.

CHARLES H. BIGELOW said that in connection with the problem of isolated plants, he had had some experience in using exhaust steam at a textile plant where there was a large demand for low pressure steam. A 500 kw. non-condensing turbine was first installed, and the exhaust steam used from that at about 8 lb. pressure. The demands for the exhaust steam were very variable, as well as the loads on the turbine; part of the time steam would be escaping through the exhaust pipe into the atmosphere, and at others the required amount would have to be made up through a reducing valve from the high pressure line.

They have since put in a 1000 kw. bleeding turbine, the load having increased, and installed a recording steam flow meter on the supply pipe to the factory. The load on the turbine was the factory load with a four or five-car traction load superimposed, the latter varying from nothing to 300 kw. almost instantaneously.

It was found from the charts that the demands for power as well as low pressure steam were very variable, but the bleeding turbine holds the pressure steady, at 10 lb., varying one pound each side of it as shown on the recording chart. The broad line is as straight as it could be drawn, showing that the regulating mechanism for holding the pressure steady in the first stage of the turbine is doing its part of the work, although it takes about two pounds variation in pressure to make it work.

Incidentally there is an indicating steam flow meter on the supply pipe to the turbine, and this swings from perhaps 15,000 to 30,000 lb. per hour, back and forth, depending on the load and the demands for steam. The bleeding turbine seems in this case to be solving the problem of supplying a variable amount of low pressure steam, without loss to the atmosphere as was formerly the case. The balance of the steam passes to the surface condenser through which the circulating water flows by gravity from a pond owned by the company and under winter conditions operates at over 29 in. vacuum. The condensate flows over a V-notch which incidentally gives a check on the two other measurements of input and the balance of output.

In regard to processes for using low pressure steam, there is a good deal of tradition in the pressure required for manufacturing processes. What is generally really required is temperature, and he wondered whether anything has ever been done to superheat low pressure steam when used in manufacturing processes.

WALTER N. POLAKOV. In this very interesting paper, the figures and curves are based on averages of actual performance, but the question is whether what has been done in the past is necessarily giving information as to what should have been done.

It has been pointed out in the discussion that in mill plants the power plant employes are usually of not very high grade. The owners try to hire the cheapest kind of help they can get, and in my experience I have found that on an average between 30 and 40 per cent of the cost of power generation can usually be saved merely by a proper method of operation, as it is not very uncommon to see firemen in a mill wasting say 5 tons of coal a day.

Comparing cost curves of private and purchased power, and assuming that large public utility power plants are also not as efficient as they might be, the rate for purchased power

will probably be reduced in the future by 20 per cent. on the average; whereas, private power cost will also probably go down some 50 per cent. In other words, the difference between the costs of private and purchased power, as shown in Figs. 1 and 2, will be much more pronounced in the future than the authors pointed out from actual experience of the past.

DAN ADAMS. This paper was intended to be a discussion of the relative value of private and purchased power, as applied to the textile industry only, and the conclusions are not applicable to any other industry, such as machine shops. Mr. Pigott has shown the great savings which can be made from bleeder turbines in this latter industry, which is very different from the textile industry.

The chief difference in regard to the heating has been brought out very clearly in Mr. Duncan's paper. Simply there is no demand, or I will say only a small demand, for heating, coincident with the demand for power; and that is due to the large amount of heat liberated from textile mill machinery, which I think is peculiar to that industry.

Prof. Williston mentioned the saving by heating from exhaust in an institution, but the same thing holds true there. Of course there is a very large saving from the use of exhaust steam for heating in any plant where the demands for power or light and heating coincide, such as office buildings or educational institutions.

It was pointed out by Mr. Bryant and Mr. Bigelow that there are difficulties in controlling the use of exhaust steam in a textile plant, in order to obtain economical results. Usually these problems can be solved, and it is a fact that most textile mills of this character use exhaust steam very generally. It was not intended in this paper to discount the savings which can be made from using exhaust steam when conditions are suitable, but it was intended to point out some of the difficulties; and we feel that some expensive mistakes have been made when it has been attempted to apply exhaust steam to these processes, without an absolutely clear and detailed analysis of all the conditions.

Mr. Bigelow also cites the case of the bleeder turbine, which is running very successfully, and there are many such cases. The bleeding of steam through a turbine is undoubtedly very economical when conditions are suitable.

In the case cited in the paper we could not seem to produce very economical results by using a bleeder turbine, and this was owing to the relation between the demand for exhaust steam and the demand for power. It was found that at times the demand for exhaust steam was more than could be bled from a standard bleeder turbine of the right capacity. For instance, the power output was 1200 kw. and the total demand for steam at times reached 50,000 lb. per hour. All that can be bled from a 1200 kw. turbine is about 12,000 lb. per hour, which was inadequate.

Now, if you use a large bleeder turbine for the sake of being able to supply exhaust steam, you will necessarily reduce the economy of the turbine, when it is not bleeding, because you are then running it at part load economy.

In this particular case, there was no use for exhaust steam whatever for something over 10 per cent of the time. The dye house was shut down on Saturday morning, which is quite common in worsted mill dye houses. The combination of all these factors resulted in a very small saving in this case, but it does not necessarily follow that it would be so in all cases.

Mr. Williston mentioned the fact that isolated plants can produce power as reliably as central stations, and this point was also brought out in the paper, that isolated power is absolutely reliable if the isolated plant has sufficient relay capacity. It should be remembered, however, that if small plants are provided with relay capacity, the investment charges run up very fast and the cost of power then approximates or exceeds the cost of purchased power.

Mr. Polakov brings out the point that the private power cost given in the paper is subject to material reductions. While it is true, as he states, that industrial power plants can on the average be improved very materially, this is less true of the textile industry than of most industries. In other words, I believe that the textile mills have devoted more attention to the economical generation of power, and this is perhaps due to the fact that they are very large consumers of power.

THE ENGINEER AND THE BUSINESS OF FIRE INSURANCE

BY JOSEPH P. GRAY,[1] BOSTON, MASS.

Non-Member

THE large Factory Mutual Companies are today, almost without exception, managed by engineers who were educated and trained in their professions. The engineer's connection with the fire insurance business was first brought about by changing conditions in the manufacturing field, which demonstrated the need of more scientific methods for the prevention of loss by fire. Previous to 1880 or 1885, the fire insurance business had been carried on wholly, even by the management of the Factory Mutual Companies, in an empirical manner. The management of the Stock Insurance Companies devoted little or no attention to questions relating to construction and protection of property. Their efforts were devoted entirely to trying to estimate or guess what was the hazard connected with a particular piece of property and to obtain from the owners a sufficient amount of premium not only to cover the hazard, but also to protect the company against losses incurred on other property where their guess had not been correct.

The management of the Factory Mutual Companies was of a somewhat broader character. Their efforts had been devoted largely to advising their members how to care for their property and to giving them what advice they could on how to protect themselves against the fire hazard. At that time, the fire hazard connected with manufacturing was much less than at present, due to slower running machinery, less haste for product, and lack of volatile oils. The fire protection at the mills was of a rather primitive character, consisting of a few standpipes, to which hose was attached, and to which were connected force pumps of limited capacity, usually located inside the mill. In some cases perforated pipe sprinklers had been provided over the more hazardous portions of the property.

I must make one exception to my statement that, previous to 1880, the fire insurance business had been carried on wholly in an empirical manner. That exception was in Lowell, and an engineer, James B. Francis, the father of hydraulic engineering in this country, was responsible for it. In 1850, the ten corporations located in that city formed a mutual agreement for the payment of all losses incurred by fire. This mutual agreement, which was really an insurance company in itself, was in effect for thirty-seven years. Mr. Francis, who

[1] Pres. Boston Manufacturers Mutual Fire Insurance Co.

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at that time was engineer and agent of the power company in Lowell, which in turn was owned by the ten corporations in question, was given full power to lay out what protection, in his opinion, the mills needed, and to adjust all losses which occurred. He made a scientific study, the first of its kind, of the question of fire prevention in mills. Under his direction, a large reservoir was constructed on Belvidere Heights and was connected by 12-in. pipes with the hydrant and standpipe systems in all the mill yards. He also had a series of tests made of the flow of water in small pipes and through small orifices. From the results obtained, a scientific system of perforated pipe sprinklers was devised, and the mills were equipped with it. Mr. Francis' efforts were to such good effect that the average yearly fire loss during the period of thirty-seven years that the mutual agreement was in effect was only five cents on each one hundred dollars of capital stock of the corporations covered by the agreement. As the property value was largely in excess of the capital stock, the actual loss per hundred dollars of value was even less than five cents. I think it can be truly stated that Mr. Francis, in addition to being the father of hydraulic engineering in this country, was also the father of fire prevention.

In 1878, Edward Atkinson assumed the presidency of the Boston Manufacturers Mutual Fire Insurance Co. He very soon realized that the changing conditions in manufacturing required a more scientific study of the fire hazards connected with it than had been given in the past. He also realized that better means must be provided for the extinguishment of fires, which, due to manufacturing operations, were constantly occurring in our manufacturing plants.

Fires had been very disastrous in woolen and paper mill plants, resulting frequently in the complete destruction of the plants. Many insurance companies were reluctant, and some refused to grant any insurance on these two classes of property. The investigations which Mr. Atkinson instituted resulted in determining that the cause of the trouble in woolen mills was largely, if not wholly, due to the character of the oil used in oiling the stock, and in the paper mills was due largely to fires which originated from hot bearings located in dark and badly constructed basements. He then employed Professor Ordway, of the Massachusetts Institute of Technology, and one of the leading chemical engineers of the country, to make a thorough investigation of wool and lubricating oils. Professor Ordway's investigation was a most complete one and resulted in new types and mixtures of oils for use in oiling wool stock. Safer types of lubricating oils, also better methods of using them, were devised by Professor Ordway. His report was submitted to the manufacturers of oils, with the request that they carry out the suggestions contained therein. Further, it was printed and distributed to the members of the Mutual Companies with the request that they buy only such oils as it advocated, and that they send samples of such oils to the insurance company for test. The final result of Professor Ordway's work and the putting of his recommendations into effect by Mr. Atkinson was the bringing of the woolen mill into the class of preferred risks and reducing largely the hazard of fire due to friction of machinery in paper mills, metal works, and other places where heavy losses had occurred from hot bearings.

At about the time that Mr. Atkinson assumed the executive management of the Factory Mutual Companies, electric lighting was invented and arc lights had been installed in some of the mills, the current being conveyed to the lights over bare copper wires. Realizing the hazard connected with this method of lighting, Mr. Atkinson employed the best electrical talent available to make a study of the problem. The result was the first set of rules for electric wiring ever devised.

The automatic sprinkler had been invented just previous to Mr. Atkinson's entering the field of fire insurance. Investigations instituted by Mr. Atkinson clearly demonstrated the value of that piece of apparatus for extinguishing fires. At the time there was only one sprinkler construction company, and the pipe sizes adopted by that company were much too small and wholly inadequate. Many of the mills were equipped with a type of fire pump which was constantly failing. Fire hose was also proving defective.

The Inspection Department connected with the Factory Mutual Companies at this time was made up of men who, while they had an excellent knowledge of manufacturing operations, had but little or no experience along engineering or scientific lines. It was evident to Mr. Atkinson that the department should be reorganized along engineering lines. One of the first men brought in by Mr. Atkinson, and one to whom the success of the department's reorganization was largely due, was John R. Freeman.

Scientific investigations were made of all kinds of apparatus. Specifications for the Underwriter fire pump were devised and put into effect to such an extent that to-day that pump is the standard fire pump the world over. Rules and requirements for installation of automatic sprinkler apparatus were also laid down. A laboratory was organized for the testing of all kinds of apparatus, this laboratory being the first of its kind in the world. Mr. Atkinson lived long enough to see this inspection department become the largest and most successful one in the world, and he is largely, if not wholly, responsible for bringing the engineer into the insurance field.

The great success attending the work of the engineers in the Inspection Department resulted, as changes were made in the management of the companies themselves, in the transfer of a number of these engineers to executive positions, until to-day the executive management of nearly all of these companies is in the hands of engineers.

The fire insurance business of the country is today in a much safer condition than it ever had been in the past. It will, I think, be acknowledged that this condition has been brought about by the work of the engineer, and his influence upon the insurance business of the country is greater to-day than ever.

In the manufacture of brass and brass products, the weight of the finished product leaving the plant is much less than the total weight of copper and zinc entering. A small part of this discrepancy is due to the unavoidable oxidation of the metals in melting, but by far the largest part of the loss is in the form of metallic particles of copper, zinc and brass. These losses occur principally at three points in the process: (a) in the casting-shop ashes; (b) in the slags from furnaces melting scrap brass; (c) in material spilled on the floor throughout the manufacturing process. The amount of these products in some plants is nearly 100 tons per 24 hours.

In general the problem of reclaiming this metal has been to free the metal from adhering slag and separate it from the associated slag, coal and cinders. On its face, this problem appears simple. That it is not simple, however, is attested by the concentrations of fine metallic particles in the sewers and stream beds of the New England brass manufacturing districts.

In the February *A. I. M. E. Bulletin* are described tests carried out on a Hardinge conical ball mill for grinding the slag while allowing the brass to be separated by screening.

MISCELLANEOUS PAPERS

FOUR-WHEEL TRUCKS FOR PASSENGER CARS

BY ROY V. WRIGHT, NEW YORK

Member of the Society

THE Pennsylvania Railroad uses four-wheel trucks under all of its passenger coaches, although the P 70 class, 70 ft. in length and having a seating capacity of 88, weigh light from 118,000 to 122,000 lb.; loaded with passengers they weigh about 135,000 lb., and never more than 140,000 lb. It is the standard practice on that system to use such trucks under all passenger equipment cars weighing less than 120,000 to 125,000 lb., except for so-called load carrying cars, including baggage-express, mail, baggage-mail, etc., which are designed to weigh over 140,000 lb. when loaded. The light

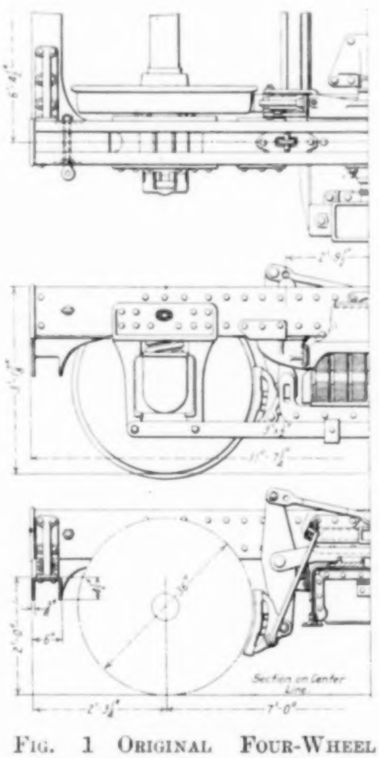

Fig. 1 Original Four-Wheel Steel Passenger Car Truck Before Application of Clasp Brakes

weight of the bodies of the Pennsylvania P 70 coaches—and these are now standard on that system—varies from 93,000 to 96,000 lb. It is assumed that these cars regularly carry as much weight in passengers and hand baggage as coaches on other roads, inasmuch as they seat 88 persons, or several more than the maximum provided for in the standard coaches of most roads. It is the practice on the great majority of railroads to use six-wheel trucks under coach bodies weighing much less than this, comparatively few roads using four-wheel trucks under bodies weighing more than 85,000 lb. and many of them using six-wheel trucks under bodies weighing even less than this.

In designing the trucks for a passenger coach four features must be kept in mind, and generally in the following order as to importance, although there may be some question as to the relative value of the last two.

a They must be designed for safety.

b They must ride smoothly, for travelers are particular as to this in these days and will desert a road with rough riding

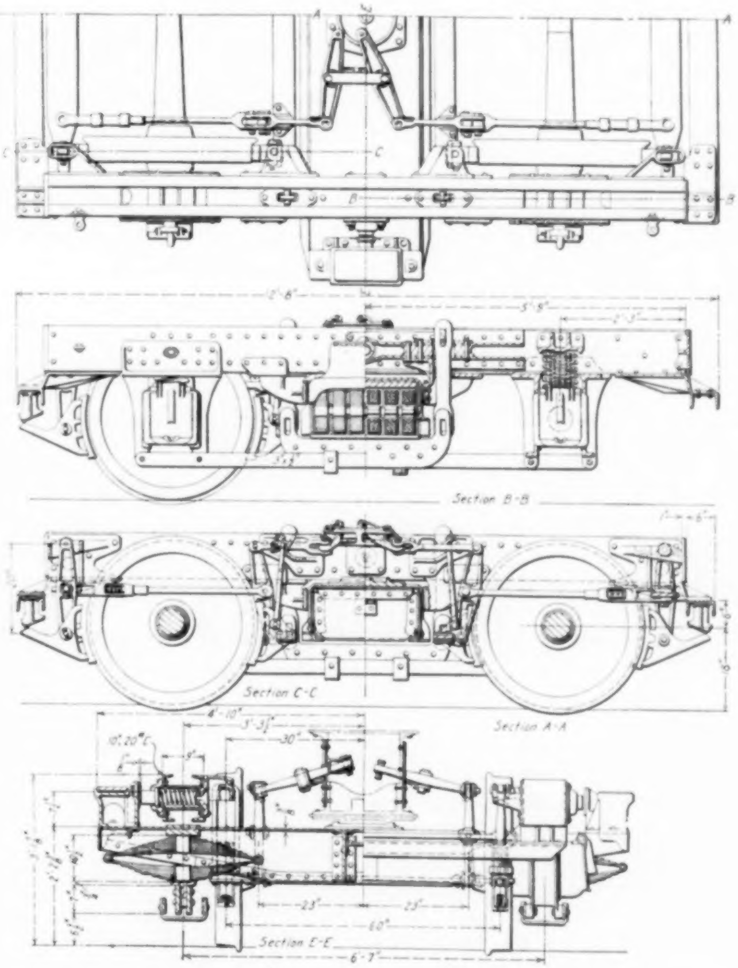

Fig. 2 Original Four-Wheel Steel Passenger Car Truck with Clasp Brakes Applied; Pennsylvania Railroad

cars if a competitor furnishes better service. With heavy steel cars operated in long trains at high speed and with the locomotives taxed to the limit of their capacity, it is difficult to operate and brake the trains without occasional roughness and jolts, and a factor such as truck design cannot be allowed to contribute further to the rough riding.

c The weight of the truck must be kept to a minimum if for no other reason than the effect on the cost of conducting transportation.

d The truck should be designed with a view to keeping the cost of maintenance as low as possible. Here, as in the

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requirement for safety, it is desirable to have as few parts as possible and of simple construction.

How does the four-wheel truck meet these requirements under the heavy passenger equipment on the Pennsylvania Railroad?

a The four-wheel truck of modern steel construction which has been in use on that system for a number of years has given splendid satisfaction so far as safety is concerned. As on other roads, some trouble has been experienced with hot boxes and it was at first thought that the journal bearing area was too small. The use of large bearing areas does not seem to have materially improved conditions and it is now believed that the difficulty is entirely due to dirt or gritty matter entering the journal boxes. The problem then becomes one of improving the journal box lid and dust guard to prevent this, rather than to increase the diameter or length of the journals.

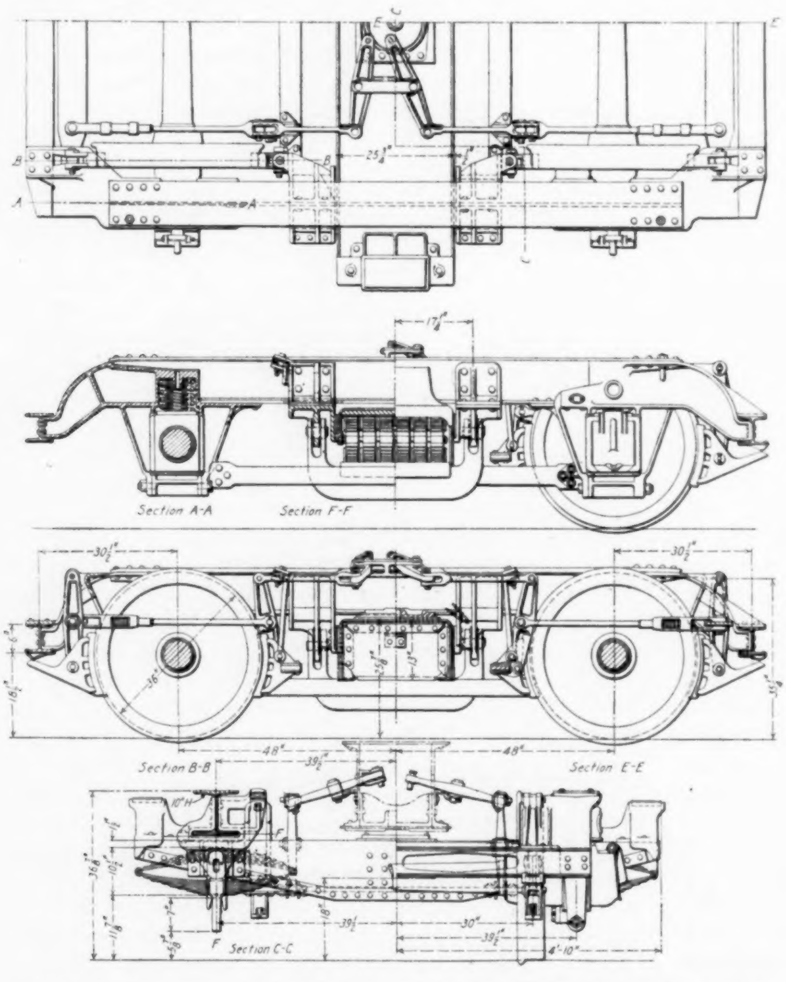

FIG. 3 PRESENT STANDARD FOUR-WHEEL STEEL PASSENGER CAR TRUCK; PENNSYLVANIA RAILROAD

There has been no breakage of axles, except for three cases due to defective material when the first steel trucks were introduced many years ago. No physical weakness has developed in any of the parts in the ten years the trucks have been in service, so that as far as safety is concerned there can be no question. The possibility of accident would seem to be less with the four-wheel truck because of the smaller number of parts required.

b There seems to be a feeling on the part of some mechanical engineers that the four-wheel truck, with its shorter wheel base (7 or 8 ft. as compared with 10 to 11 ft. for the six-wheel truck) will ride less easily than the six-wheel truck. With coil springs over the journals, elliptical springs under the bolster, and provision for lateral motion of the bolster, it would seem that there ought not be much difference in this respect.

Experiments show that much of the rough riding or jolting on passenger coaches has been due to the method of anchoring the top of the dead lever to the truck frame. The unbalanced forces in the truck when the brakes are applied tend to tilt the truck frame out of horizontal alignment, thus causing a "jerky" action. By anchoring the dead lever to the body underframe this is eliminated. This development is comparatively recent and affects the six-wheel as well as the four-wheel truck. The effect of anchoring the dead lever to the truck frame has possibly been more noticeable on the four-wheel truck, because 1— to —1 dead levers are used, resulting in a greater pull on the frame than in the case of the six-wheel truck; then, too, the resisting moment is less because of the shorter wheel base of the four-wheel truck. This improvement has been patented.

c There is a wide variation in the weights of different types of steel passenger car trucks, but it is probably fair to state that a pair of four-wheel trucks will weigh from 10,000 to 15,000 lb., or more, less than a pair of six-wheel trucks having the same carrying capacity. In other words, for the same total weight of car the one with four-wheel trucks will carry 10,000 to 15,000 lb. more lading or body weight, or with the same weight of body the total weight of the car with four-wheel trucks will be from 10,000 to 15,000 lb. less than the one with six-wheel trucks. For a car weighing 120,000 lb. and equipped with four-wheel trucks this means a saving of from 8 to 11 per cent in total weight as compared with what it would be if six-wheel trucks were used. On most roads it is the practice to carry car bodies weighing more than 85,000 lb. on six-wheel trucks, which weigh fully 15,000 lb. per car more than four-wheel trucks. A locomotive that can haul eight cars equipped with such six-wheel trucks over a given division will haul nine cars of the same seating capacity having four-wheel trucks—a saving much to be desired.

d Roughly speaking, the cost of maintenance of a steel passenger car truck may be said to be very nearly in proportion to the number of its wheels and axles, those with the brake shoes being the parts subjected to the greatest wear and requiring frequent repairs and renewals. While no exhaustive data are available as to the comparative cost of repairs and maintenance of six-wheel and four-wheel trucks of the same carrying capacity, they are said by those who have checked these costs to be at least 50 per cent greater for the six-wheel truck.

As a partial check on these conclusions, it is proposed to review briefly the development of the four-wheel steel truck for passenger cars on the Pennsylvania Railroad. From the outset and throughout this development the aim has been to reduce the number of parts to a minimum and make the construction as simple as possible.

In designing the first four-wheel steel trucks in the early

part of 1905, it was aimed to use them under the largest coach possible and keep within the M.C.B. load limits for 5-in. by 9-in. axles. Shortly after the trucks had been placed in service, three of the axles broke in the wheel seat where the stress is least. Investigation finally showed that the breakage was due to defects in manufacturing caused by a faulty furnace which had been discarded shortly after these axles were made. In the meantime, however, as a measure of absolute safety, it was decided to increase the axles on existing cars ½ in. in diameter and on new cars to go to the next larger size standard M.C.B. axle, the 5½-in. by 10-in. Because of hot box troubles the length of journal was afterward increased to 11 in., although experience has since indicated, as previously noted, that the trouble was probably due more to dirt getting into the journal box than the lack of journal bearing area. The 5½-in. by 11-in. journal is now standard for all four-wheel and six-wheel trucks.

In going from the wood to the steel construction spring planks, axle guards and brake beams were done away with, the brake levers being attached directly to the brake heads. Each side frame was formed of two 10-in. 20-lb. channels, with the flanges turned inward and forming a box girder construction. The channels were spaced so as to measure 9 in. overall. This was done to provide sufficient strength for resisting the lateral stresses, a requirement which has been overlooked in some designs. To check or limit the lateral motion or swaying of the bolster a spring arrangement was used, as shown in the drawing (Fig. 2).

The subsequent use of clasp brakes made it necessary to modify this design somewhat. Fig. 2 shows the details of this modified design, which in general is practically the same as the original design, other than the braking arrangement, except for changes in the end construction of the frame to provide for the outside brakes. The detail of the original end construction is shown in Fig. 1. The end rail in the original design, which was formed of a ⅜-in. plate pressed in the form of an inverted U, 6 in. in width, was changed to make room for the brake levers. The outside brakeheads in the case of the clasp brakes are attached to the lower ends of the brake levers, which are anchored at the top to castings riveted to the ends of the side frames. A 6-in. channel with flanges turned downward connects these castings and forms the end rail. It was also necessary to add brakehead tie bars because of the impossibility of connecting the tension rods for the outer brakeheads direct to the brake lever. It should be noted, however, that this brakehead tie bar is a simple rectangular bar and that the brake tension rod connects to it as close to the brakehead as possible. Obviously the weight and the cost of maintenance of this tie bar is much less than for a brakebeam where the force is applied at the middle. All of the brake levers, including the dead and live levers, are of the same size and interchangeable except for drilling.

The peculiar form of the outer brakehead is noticeable. In the first application of the clasp brakes the ordinary type of brakehead was used with springs to hold it balanced when hanging loose. These springs were difficult to maintain and were done away with by redesigning the brakehead and adding the tail piece. When the brakehead hangs loose this tail piece rests against a casting which is riveted to the underside of the end rail. When the brake is applied there is a clearance of ½ in. between the brakehead tail piece and the rest. This device has given most satisfactory results.

The next development was a modification of this design to provide for the application of a motor for use under motor cars on electrified divisions. To do this it was found necessary to increase the wheel base from 7 ft. to 8 ft. 6 in. Transoms were also added to support the lip of the motor and the bolster design was modified slightly; otherwise the same parts were used as in the original design.

The next development was a radical one, the box girder side-frame being replaced by a Bethlehem 10-in. 54-lb. H-beam, thus simplifying the design as to construction by reducing the number of parts and still providing sufficient moment to resist the side stresses. As shown in Fig. 3, the journal box pedestal casting has a projection to which the top of the lever for the outside brake is anchored and which also supports the end rail, a 6-in. H-beam. The H-beam which forms the side frame has its lower flange and web cut away over part of the journal box pedestal casting and is strongly riveted to it through both the upper and lower flanges. The casting which was formerly used on the end rail to balance the brakehead was replaced by a steel clip which is sprung over and welded to the lower flanges of the end rail.

Another noticeable change was the shortening of the bolster hangers, thus limiting the amount of side swing and making it possible to do away with the complicated spring mechanism which was formerly used to check and limit the lateral motion of the bolster with the longer hangers. Before making this change, the springs were gradually blocked and finally wedged solid on a number of the cars. As this had no noticeable effect on the smooth riding, it was decided to discard the springs entirely.

The more important of these changes, that is, the side frame construction and the change in the hanging of the bolster, were first made on four-wheel trucks for suburban cars, several hundred of which were built. These trucks, however, were of lighter construction than those used under the standard coaches and are not considered in this discussion. The details of this improved truck as designed for use under standard coaches are shown in Fig. 3.

The paper concludes with a description of a modification of this standard truck made necessary by the Philadelphia-Paoli electrification of the main line of the Pennsylvania Railroad.

DISCUSSION

Geo. R. Henderson (written). In reading Mr. Wright's very interesting paper, the writer's thoughts followed the abandonment of the equalizers which for so many years were considered necessary for easy riding, especially on rough track. It is well known that the Pennsylvania track is nearly perfect and it is a question whether these trucks and loads would be satisfactory on average track. This accounts for a considerable saving in weight, as the equalizer and spring seats were quite massive for heavy cars.

It is still the practice of many roads to use equalizers under tenders of passenger locomotives and also under high speed electric cars, and it is an interesting question as to just how far we can go in this respect and still not interfere with the comfort of the passengers. The condition of the track is a very important part of the problem in the writer's estimation and should not be overlooked when considering this question.

S. G. Thomson said that the clasp brake as used on the Philadelphia and Reading Railway, to-day, was giving most excellent satisfaction, and has done so ever since it was developed. One hundred and fifty or more cars have been in service for a number of years, and little or no difficulty has been experienced. The brake is highly efficient and the stops seem to be very much easier and shorter than with the single shoe and higher brake-shoe pressure.

In regard to the question of journal lubrication, he had found that at 80 or 90 miles per hour, some trouble was experienced from hot boxes. Careful readings of journal box temperatures seemed to indicate that the temperatures build up during closely consecutive runs, the wheels and journals not having had time to cool down before the return trips. During the rush season it was often necessary to schedule certain cars for six trips per day, equal to 300 miles or more. The cars were all-steel, weighing about 118,000 lb., which seem to be, in his judgment, about the limiting weight for four-wheel trucks at these high speeds, particularly where they are closely consecutive.

He thought, therefore, that the factor of speed seems to have a fundamental bearing on the question of the use of the four or six-wheel trucks on modern passenger equipment, and that the four-wheel truck should prove entirely satisfactory for anything less than the weights or high speeds on consecutive trips as has just been mentioned.

L. R. Pomeroy said it was astonishing how much money railroads spend to get another car on a train, to be hauled with the same engine, where the cost is more than it would be to run cars with logical trucks. He thought it was quite true that six-wheel trucks have been developed more generally in the West, and it is only in recent years that they have become general on ordinary passenger coaches.

In the West some of the reasons why the six-wheel truck was adopted on cars which would now be considered light were the very light gravel ballast, light rails (from 60 to 70 lb.), and cast iron wheels.

He presented the following figures of weights of four and six-wheel steel trucks under steel cars:

Four-wheel trucks on the Harriman Lines, 5 x 9 journals; weight 26,500 lb. complete. Western Pacific, 5½ x 10 journals; 31,120 lb. complete. Barney & Smith special built-up truck, similar to the Atlantic Coast Line, 5 x 9 journals; 27,600 lb. complete. N. Y., N. H. & H. R. R. standard trucks, 31,400 lb. complete.

Six-wheel steel trucks on the Harriman Lines, 5 x 9 journals; 42,000 lb. complete. Rock Island, 5 x 9 journals; 41,220 lb. complete. Commonwealth, 5 x 9 journals; 40,900 lb. complete. Pullman standard truck, 5 x 9 journals; 43,720 lb. complete. New York Central latest form of steel truck, 45,000 lb. complete. The latter weighs considerably more than the average of the others, and is partly accounted for by being equipped with clasp brakes. Barney & Smith built-up truck, 5 x 9 journals; 42,000 lb. complete. Canadian Pacific trucks under 70-ft. diners, 41,200 lb. complete. Canadian Pacific under sleepers 72 ft. 8 in. long, 40,900 lb. complete; under sleepers 70 ft. 3 in. long, 41,800 lb. complete; under sleepers 74 ft. long, 41,800 lb. complete.

He did not think that even under ordinary conditions of service, there is any justification whatever for a six-wheel truck under a suburban car, and yet a great number are running on these trucks. He said he had never yet come across a 70-ft. car of the ordinary passenger coach type where the six-wheel truck was justified with the track in use to-day.

The Wabash has a 60-ft. all-steel mail car, 5 x 9 journals, six-wheel trucks, total weight 124,000 lb. The trucks weigh 42,000 lb. With four-wheel trucks, 27,000 lb., the total weight would be 109,000 lb. We have a great many cars that weigh as much as 124,000 lb. running successfully with four-wheel trucks.

There are two classes of six-wheel steel passenger cars on the New York Central, the earlier form with equalizers, in connection with Commonwealth frames, and the latter with half elliptic springs over boxes and short equalizers between the springs. The total weight of the car is 142,000 lb. and that of the six-wheel trucks 42,000 lb. With four-wheel trucks the total weight would be 127,000 lb. There are a number of cars of no greater weight running to-day on four-wheel trucks.

On the 63-ft. 78-passenger cars of the Central Railroad of New Jersey, Commonwealth trucks, with 5½ x 10 journals, are used. The total weight is 115,800 lb. With six-wheel trucks the total weight would be 131,800 lb.

The body of the N. Y., N. H. & H. R. R. 1914-schedule 70-ft. 88-passenger car weighs 89,000 lb. Add the weight of a six-wheel truck, 42,000 lb., and the total weight would be 131,000 lb. In later cars the four-wheel standard type truck was substituted. The heavy four-wheel truck weighs 31,400 lb. and has a 5½ x 10 journal, and it brings the total weight of the car to 121,400 lb. on four-wheel trucks. These cars are giving excellent satisfaction in respect to freedom from hot boxes, and comfortable riding.

The Grand Trunk composite steel frame wood finish car, 74 ft. long, seating 97 passengers, weighs 137,000 lb. Deducting the weight of the six-wheel truck, 40,000 lb., leaves 97,000 lb. Adding the weight of the four-wheel truck, 27,000 lb., makes 124,000 lb. Those figures are well within the capacity of the four-wheel truck.

The total weight of the Union Pacific 69-ft. steel truck baggage car is 106,000 lb. With six-wheel truck it would weigh 122,000 lb.

The Postal 60-ft. four-wheel truck car has a total weight of 111,600 lb., which would be increased to 127,600 with the six-wheel truck.

The Lehigh Valley has a steel well flat car, with a capacity of 220,000 lb. The light weight is 91,900 lb., making the total loaded weight 311,900 lb. The car has a six-wheel truck, with 6 x 11 journals, and yet the ratio of total weight of the car against the projected area of the journal is only 475.

The Santa Fé has a 70-ft. 83-passenger all-steel car which weighs 134,000 lb. and has six-wheel trucks; with four-wheel trucks it would weigh 118,000 lb. The 70-ft. 76-passenger chair car on the same road weighs 136,000 lb. and has six-wheel trucks; with four-wheel trucks it would weigh 120,000 lb. It will be seen, also, that these cars could be properly put on four-wheel trucks.

Geo. W. Rink. I would ask Mr. Thomson whether the type of truck which gave trouble with hot journals was that with the coil spring over the journal box. We had this type of truck[1] in service on twenty-eight 63-ft. passenger cars weighing 101,400 lb. The trucks had 5½ by 10-in. journals and clasp brakes and weighed 14,500 lb. each.

The wheel beam is made up of an eye beam and two channels and the transoms of cast steel riveted to the wheel beam. The elliptic springs are carried in a cradle suspended by U-shaped spring hangers. Pedestals are of cast steel, riveted to wheel beams, and are provided with spring pocket. On trucks of this type it is very essential that holes be reamed and the rivets fill the holes, otherwise there will be trouble in maintenance.

We had a number of cases of hot journals on these trucks when first placed in service. There is a tendency in this construction to so distribute the pressure on top of box as to cause an excess pressure per square inch on the journal bearing. We also found a strong tendency for the journal boxes to bind in such a manner that they were thrown in or out, due to

[1] Railway Age Gazette, August 16, 1912, p. 279.

the action of the coiled spring over the box, resulting in excessive wear of box flange and pedestals. This truck also gave trouble from loose rivets.

We are now using on our 63-ft. steel coaches and combination cars, weighing 116,000 lb. and seating 78 and 51 passengers respectively, a cast steel truck[2] with 5½ by 10-in. axle, and with wheel beams, transoms and end sills cast in one piece. The truck weighs 16,100 lb., and with generator and truck suspension 17,600 lb. These trucks have cast iron pedestals of heavy pattern bolted to the wheel beams, and have the long equalizer with coil spring adjacent to the journal boxes and the same type of clasp brake as used on the built-up truck. We do not use the same type of clasp brake as used by the Pennsylvania Railroad, but use standard brake beams.

These trucks ride very smoothly and seldom have heated bearings. We now have 126 steel coaches in service with this truck giving excellent results, fully complying with the four important features as mentioned by the author—safety, smooth riding, minimum weight, and low cost of maintenance.

ALPHONSE A. ADLER asked whether, in car truck journals, the resistance of friction is dependent on the load, or whether it is possible to so adjust the load that there is perfect film lubrication and the resistance is only proportional to the size of the journal.

E. B. KATTE said that while they have made several attempts to design a six-wheel motor car truck, they have not arrived at a design which is satisfactory from either a mechanical or an electrical standpoint, and he did not know of any six-wheel motor car trucks in high speed service.

C. D. YOUNG. Railroads have been too prone in recent years to use six-wheel trucks, based upon their experience with four and six-wheel trucks in the days before the advent of the steel truck. Due to the flexure in the wooden trucks it was necessary to go to the six-wheel truck. As far as the probable cost and maintenance are concerned, due to the fewer parts, the four-wheel truck is preferable to the six-wheel truck, provided it gives satisfactory service.

With the use of the steel truck the total weight which will be satisfactorily carried on the four-wheel truck car can be materially increased. Ninety-eight per cent of the railroads in this country use four-wheel trucks under heavy passenger locomotive tenders, with axle loads as high as 45,000 lb., yet when a passenger car is designed there is hesitancy about putting 31,000 lb. on the same axle.

To ascertain what effect on the train resistance the two extra axles of the six-wheel truck car would have, we took the same car bodies in a train of 10 cars and compared the resistance of the train when carried on four-wheel trucks, similar to that illustrated in the paper, with that when these cars were carried on the six-wheel standard trucks of the Pennsylvania Railroad. The trains were run at 35, 50 and 65 miles per hour. Three round trips were made and the resistance of the cars was obtained. It was found that 13 six-wheel truck cars offered the same resistance as 14 four-wheel truck cars; in other words, if on a train of 13 cars the equipment is changed from six-wheel trucks to four-wheel trucks, one more four-wheel truck car can be hauled without increasing the resistance over that of the 13 six-wheel truck cars.

The author shows the development of the clasp brake for the four-wheel truck cars, which came about as a result of clasp brakes used on the Philadelphia & Reading Railway. In this connection, two or three points which were brought out in a series of tests made by the Pennsylvania Railroad of clasp and single shoe brakes, are of interest.

The single shoe brake has a total weight of 3682 lb. per car and the movable parts weigh 3084 lb. The clasp brake has a total weight of 4433 lb. per car, the movable parts weighing 3152 lb., showing an increase in total weight of the clasp brakes of 24 per cent. It was developed in our tests that it was desirable to have as low weight in the moving parts of the brake rigging as possible to overcome the effect of inertia on the first application of the brakes, for obviously the heavier the moving parts the more inertia and the longer it takes to get full braking pressure at the wheel with a given pressure in the brake cylinder. With equal weights of movable parts, it would be expected that full braking power would be developed as quickly with the clasp brake as with the single shoe brake, but for a given braking power a higher coefficient of brake shoe friction is obtained with the clasp brake car and, therefore, the stops are shorter than with the single shoe brake car.

To illustrate this, at 60 miles an hour with 125 per cent nominal braking power the clasp brake car made a stop in 808 ft., probably the shortest stop ever made on a passenger car under that braking power. The corresponding stopping distance for a single shoe is about 1250 ft., so that with 24 per cent increase in weight of brake rigging there is, with the clasp brake car, a much larger per cent decrease in the stopping distance.

Another point which cannot be ignored is that the use of the clasp brake is economical in brake shoe material. A series of road tests of brake shoes shows a saving in brake shoe material of about 30 per cent with clasp brakes over single shoe brakes.

In reply to Mr. Adler, the friction of the journals of a car running at 50 miles an hour offers such a small resistance compared with the resistance due to wind, flange, oscillation and other causes, that it has a small value in any empirical formula used to determine total resistance.

THE AUTHOR. Six-wheel trucks are used extensively and there must be good reasons for this. These reasons have not, however, been brought out in the discussion. It is a severe indictment of the mechanical departments of our railroads if the use of six-wheel trucks under modern railway equipment has simply come about because in the days gone by, when wooden trucks were in use, it was found desirable to use six-wheel trucks under much of the equipment.

Mr. Henderson's discussion brings up a point which might account for the use of the six-wheel truck in the Far West, and that is that where road conditions are poor, there is a possibility that the six-wheel truck may ride more easily. On most of the sections of the roads in the East which still have poor roadbeds, old light wooden cars with four-wheel trucks are used. There is, however, a grade of track between the magnificent roadbed, which we have on the high traffic eastern lines, and the very poor condition; and, generally speaking, on that kind of track the four-wheel trucks ride just as easily as do the six-wheel trucks.

The latest type of standard four-wheel passenger car truck, modified for use under motor cars on the electrified district of the Pennsylvania Railroad at Philadelphia, is illustrated in the paper, and it is interesting to note how skillfully the designers have taken advantage of the standard design and modified it only slightly to allow for the motors, which are the largest thus far used under motor cars.

[2] Railway Age Gazette, Mechanical Edition, December, 1914, p. 627.

THE FLOW OF AIR THROUGH THIN PLATE ORIFICES

BY ERNEST O. HICKSTEIN, STAPLETON, N. Y.

Junior Member of the Society

THIS paper reports an interesting and instructive investigation made by a Junior Member. It bears the distinction of being the Junior Prize paper for 1915, and is the first paper to receive a prize from the Society, the fund from which it was awarded having been established in 1914.

This paper describes in some detail the methods used by a large pipe-line company in the Mid-Continental field in the calibrating of its orifice meter discs.

An orifice meter consists of a calibrated disc in a pipe-line, with pressure line connections running to two indicating or recording gages; one gage is for measuring the static pressure

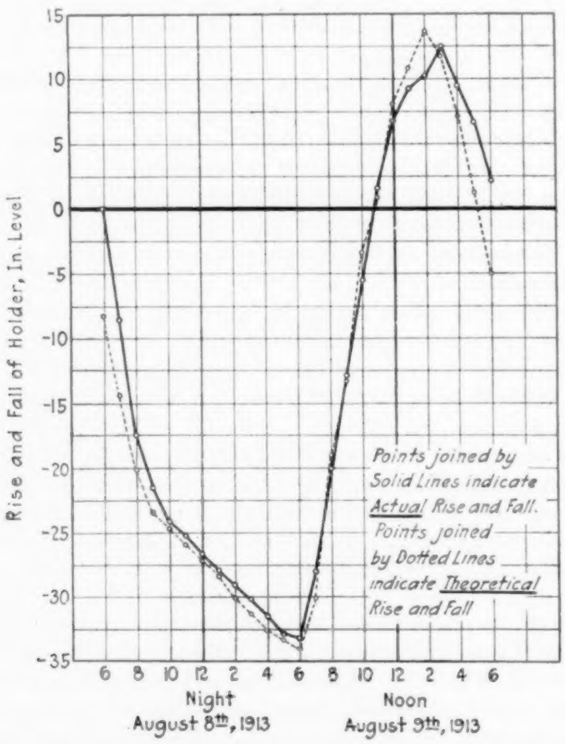

FIG. 1 ACTUAL AND THEORETICAL RISE AND FALL OF HOLDER, UNDER TEMPERATURE CHANGES. FIRST 24-HR. TEST

of the flowing gas and the second the differential drop of pressure across the orifice disc.

The discs tested are machined out of quarter-inch boiler plate. The edge of the orifice is flat for $\frac{1}{32}$ in. and bevelled at 45 deg. for the remainder of the thickness. The disc is inserted in the flange union with the bevel facing the outlet side.

The ordinary practice in orifice meter installations is to have the gage line connections right at the flange, that is, the inlet and the outlet pressures are taken within an inch or two of the orifice disc. In this particular, the meters of the type tested show a departure from common practice. The high pressure connection was $2\frac{1}{2}$ times the diameter of the pipe line ahead of the disc, and the low pressure connection was 8 times the diameter of the pipe line behind the disc. This means that in an orifice meter installation on a 10-in. line, for example, the high pressure connection is 25 in. in front of the disc, and the low pressure connection 80 in. behind it, regardless of the size of the orifice in the line.

The paper deduces the following general formula for the flow of air through an orifice disc:

$$Q_o = C_a\sqrt{hP_1}$$

where

Q_o = volume at standard temperature and pressure
C_a = so-called "air constant," found experimentally
h = differential in in. of water
P_1 = pressure at inlet of orifice

The tests were carried out at Joplin, Mo. The discs were calibrated against the displacement of air from an old artificial gas holder at that place. The holder was a two-lift holder, water sealed and of 250,000 cu. ft. nominal capacity. Roughly speaking, its dimensions were 90 ft. in diameter by 40 ft. total height. The lower lift only was used in the tests; this lift has a capacity of 110,000 cu. ft.

Of the several original outlets from the holder, all but one were securely blanked. The remaining 12-in. outlet was led into a long building, and connected to a straight run of some 40 ft. of pipe, near the center of which was the orifice flange. The air passing out of the holder went through the orifice disc, and discharged into the atmosphere perhaps 20 ft. beyond. A motor driven blower was used to fill the holder with air previous to each test.

Leakage Tests on Holder. The first tests made were to determine the rate of leakage from the holder. In order to obtain a fair average, a number of such tests were run at the start, with the holder at varying heights. Leakage tests were also run at intervals throughout the whole work, to make sure that the leakage figure first obtained had not materially changed.

The first leakage tests were unsatisfactory on account of the large difference between temperature conditions at the start and finish of test. To avoid this difficulty, tests of 24 hours duration, starting at about midnight, were made, and better results obtained. The average of three long leakage tests showed 103 cu. ft. leakage per hr. The correction used in all the Joplin tests was taken as 100 cu. ft. per hr. The result of later leakage tests showed practically the same leakage as the above average, the highest value in any 24-hr. test being 115 cu. ft. per hr.

Changes of Volume in Holder with Temperature Variation. During the leakage tests, it was noticed that the rise and fall of the holder with temperature changes was a greater factor than had been anticipated. A 4-ft. rise from midnight to noon was not uncommon during the hot weather. It was necessary, therefore, to ascertain very accurately the proper correction to apply for temperature changes taking place during a test.

It was found that the changes in volume as observed were always greater than a calculation based on the ratio of absolute temperatures alone would give. After some little study and debating, it was decided that this was due to the presence of aqueous vapor in the holder.

In studying the correction to be applied for varying temperatures, taking account of the effect of the vapor tension, it was found in the study of the volume variation with temperature that the observed rise and fall of the holder during the test corresponded with a temperature change equal to the sum of two-thirds the atmospheric temperature, plus one-third the "top" temperature, the "top" temperature being the reading found by lowering a thermometer 2 ft. or so into the holder through a bolt hole in top. This simply means, of

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course, that the average temperature of the holder air is that combination of the two observed temperatures.

Fig. 1 shows a test of the correctness of this average temperature of the holder air. The dotted curve shows the computed theoretical rise and fall of the holder, using the temperature correction just described, and based on the so-called "combined" temperature. The heavy curve shows the actual rise and fall observed. These two curves follow each other fairly well, except for a lag during the middle of the day. They bear the closest relation during the period between 9 P.M. and 6 A.M., when the effect of the sun shining down on the black holder top is not present. During the afternoon it is evident that the "top" temperature has a greater proportionate effect on the average temperature of the air in the holder than the "combined" temperature allows.

PROCEDURE DURING TESTS

Table 1 shows a sample page of the observations and calculated results of one orifice test. These tests were made with a flying start, that is, the air was started discharging through the meter orifice several minutes before the first tank level reading was taken. The final tank level reading was taken under similar conditions. Half-hourly readings of atmospheric temperature, "top" temperature, tank level, water level in seal, differential drop in inches of water across orifice disc, and the temperature of the discharged air were taken. To facilitate calculation, the tank level reading was taken by a gage stick, marked off in cubic feet displacement. The exact diameter of the lower lift was found, and from this it was computed that a displacement of 100 cu. ft. corresponded with a holder drop of 0.1835 in. This 100-ft. graduation was the smallest on the gage stick. The space could readily be divided visually into quarters, so the content of the holder at any moment could be read to the nearest 25 cu. ft. Differences between two consecutive half-hourly tank level readings would therefore give the uncorrected (or apparent) quantity of air passing out in that period. Preliminary corrections have to be applied to this value as follows: (1) holder leakage, at the rate of 100 cu. ft. per hr., (2) variation of the water level in seal, due to leakage out, evaporation, or pumping in of fresh water, (3) temperature change during test. With these corrections applied, the correct quantity of air passing through the orifice is obtained. This quantity, however, is expressed at holder pressure, and at some definite temperature, varying from day to day, i.e., the "combined" temperature. A reduction is necessary in order that the quantity of air passing through the orifice may be expressed in cubic feet at standard conditions of pressure and temperature, (29.4 in. of mercury or 14.41 lb. per sq. in., and 60 deg. fahr.).

SUMMARY OF RESULTS

About one hundred and sixty tests on 8 and 10-in. orifice meter discs were run at Joplin during 1913-1914. A summary of some of the results of these tests is included in Tables 2 and 3. A note on the system used in numbering the discs will make the summary self-explanatory. The first one or two digits indicate the size of the pipe line in which the disc

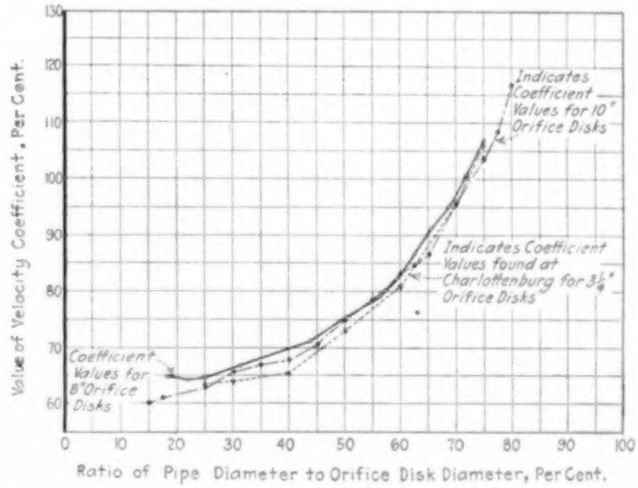

FIG. 2 COMPARISON OF VELOCITY COEFFICIENTS OF ORIFICE METER DISCS, AS FOUND IN JOPLIN TESTS FOR 8-IN. AND 10-IN PIPE LINES, WITH VALUES FOUND AT CHARLOTTENBURG

TABLE 1 READINGS AND CALCULATED RESULTS OF A SAMPLE HOLDER TEST ON ORIFICE METER DISC

Time	Temperatures: Atmos.	Temperatures: "Top"	Temperatures: Orifice	Gage Stick Reading	U-Tube In. Water	Calculated (Apparent) Displacement in ½ hr.	"Combined" Temp.	Correction for Temp. Changes	Calculations
8.15	66	66	66	252,675	4.39	....	66	.....	
8.45	67½	....	65	244,050	4.39	8,625	66	0	
9.15	67	66	65	236,350	4.38	7,700	66⅔	330	Apparent total.... 108,975
									Seal water correction........... —140
9.45	66	....	64½	228,125	4.37	8,225	66	—320	
10.15	66	64½	64	219,725	4.36	8,400	65½	—230	Leakage corr...... —650
10.45	66	....	64	210,950	4.36	8,775	65½	0	Temperature corr.. —960
11.15	65½	63½	63½	202,325	4.35	8,625	65	—210	
11.45	65½	....	63½	193,700	4.35	8,625	65	0	Net total.........107,225
12.15	65½	63	63½	185,625	4.34	8,075	64½	—200	Average flow...... 8,248
12.45	65	....	63½	177,175	4.32	8,450	64½	0	Calculated C_A.... .520
1.15	65	63	63½	168,850	4.30	8,325	64½	0	Calculated C_V.... 67.3%
1.45	64½	....	63	160,425	4.28	8,425	64	—170	(see footnote)
2.15	64	62½	63	152,070	4.26	8,350	63½	—160	
2.45	64	....	63	143,700	4.24	8,375	63½	0	
			64		4.34	108,975	65	—960	

Test No 227, Nov. 12, 1913. Orifice Disc No. 8301. Barometer 29.35 in.
C_V = so-called "velocity coefficient" depending on size and shape of disc. $C_V = 11.55 \; C_A \div D^2$

TABLE 2 SUMMARY OF SOME HOLDER TESTS ON 8-IN. ORIFICE METERS

Test No.	No. of Meter Disc	Date of Test and Duration in Hr.	Avg. Corr. Rate. Cu. ft. /30m.	U-Tube Reading, In. Water	Barometer.	Observed Temp.: Flow	Observed Temp.: "Combined"	Calc. C_A
201	8401	Sept. 25 1½	15,503	4.07	29.3	58	52	1.035
202	8501	26 2	25,361	3.31	29.3	62	56	1.868
203	8301	26 3	8,178	4.415	29.3	58	54	0.522
204	8351	27 3	11,671	4.26	29.3	62	60	0.752
205	8451	27 3	20,223	3.82	29.3	62	60	1.375
206	8451	28 2	20,589	3.79	29.2	64	61	1.409
207	8351	28 3	11,668	4.33	29.2	61½	60	0.747
208	8401	28 2½	15,796	4.11	29.2	61	58	1.041
209	8351	30 2½	11,850	4.31	29.3	66	62	0.759
210	8451	30 2	20,421	3.83	29.3	64	59	1.394
211	8501	Oct. 2 1½	26,647	3.36	29.3	70	67	1.914
212	8501	2 1½	26,187	3.40	29.3	67½	63	1.883
213	8401	2 2½	15,839	4.14	29.3	65	60½	1.038
214	8301	3 2½	6,124	2.355	29.3	70	69	0.527
215	8301	4 5½	8,496	4.41	29.2	70	70½	0.532

TABLE 3 SUMMARY OF SOME HOLDER TESTS ON 10-IN. ORIFICE METERS

Test No.	No. of Meter Disc	Date of Test and Duration in Hr.	Avg. Corr. Rate. Cu. ft. /30m.	U-Tube Reading, In. Water	Barometer, In. Hg.	Observed Temp. Flow	Observed Temp. "Combined"	Calc. C_A
401	10401	Dec 20 3	13,978	4.345	29.4	48	32	0.9286
402	10501	20 2	23,156	3.94	29.5	47	32½	1.611
403	10501	20 2	23,138	3.94	29.4	48½	31	1.620
404	10801	26 1	53,855	1.38	29.4	45	29½	6.384
405	10751	21 1	49,513	1.89	29.5	48	33½	4.983
406	10801	21 1	53,975	1.38	29.3	50	35	6.370
407	10801	22 ½	55,595	1.43	29.2	48	36	6.429
408	10751	22 1	50,575	1.95	29.2	49	35	5.025
409	10501	23 2	23,209	3.95	29.2	49	32½	1.626
410	10401	23 3½	14,189	4.38	29.2	48	33	0.9406
411	10551	22 1½	29,042	3.89	29.2	48	35½	2.035
412	10551	26 1½	28,225	3.68	29.4	45	26½	2.055
413	10751	27 1	48,850	1.90	29.4	48	36½	4.976
414	10801	27 ¾	55,220	1.39	29.4	49	37	6.450
415	10501	27 2	21,080	3.28	29.4	49	35½	1.605

is inserted; the next two digits, the size of the orifice; the remaining digits, the serial number of the disc. For example, 8473 would represent an 8-in. meter disc, 4¾-in. orifice; 104211 is a 10-in. disc, 4¼-in. orifice, etc. It was found necessary to discard perhaps half a dozen tests, on account of their disagreeing widely from the averages of the remainder. In two or three of these discarded tests, a shower or a fall of snow during the test furnishes a possible explanation; in other tests, no explanation was found.

It is worthy of special note that in these tests the standard used is an actual measurable volume, and not a standardized pitot tube or other indirect method of measurement. The advantage of being able to calibrate directly against displacement is a most important feature of these holder tests. A second feature of the tests is the ability to automatically secure a practically constant flow, without regulation of any kind.

Another point deserving mention is the fact that duplicate discs of sizes already tested at Joplin require no calibration of any kind. It is merely necessary to micrometer the orifice and to correct mathematically for any small deviation from the nominal diameter. For example, if a new 8-in. by 4-in. orifice disc micrometers 4.004 in. in diameter, and the result of the Joplin tests on the master 8-in. by 4-in. orifice be 1.034,

TABLE 4 SUMMARY OF VALUES PLOTTED

Joplin 8-in.		Joplin 10-in.		Charlottenburg 3¼ in.	
d/D	C_v	d/D	C_v	d/D	C_v
0.1875	64.9	0.15	60.1	0.25	63.5
0.219	64.2	0.175	61.1	0.30	64.0
0.25	64.7	0.25	62.8	0.40	65.5
0.3125	66.9	0.30	65.6	0.50	73.0
0.375	67.9	0.35	66.9	0.60	81.0
0.4375	71.1	0.40	67.9	0.70	96.0
0.50	75.3	0.45	70.4	0.75	106.0
0.5625	79.0	0.50	74.9		
0.594	82.2	0.55	78.7		
0.625	86.6	0.60	83.2		
0.655	91.3	0.625	84.6		
0.6875	95.3	0.65	86.6		
0.7187	100.7	0.70	95.9		
0.75	107.0	0.75	103.5		
		0.80	116.6		

the value of C_a for the slightly oversized disc would be 1.034 $(4.004 \div 4.000)^2$ or 1.036.

The only published report[1] of tests made on orifice discs similar to those tested at Joplin gives the values of the velocity coefficient, C_v, for 3¼-in. pipe found in tests made at Charlottenburg, Germany. Fig. 2 shows graphically the values found at Charlottenburg compared with the Joplin results for 8 and 10-in. pipe. The Joplin curves agree fairly well with the Charlottenburg values, especially if the difference in the pipe sizes is taken into account.

CONCLUSION

Nearly fifty orifice meters have been installed and are now in operation, their deliveries of high pressure gas being calculated from the air constants found in the Joplin tests. Experiments which are now in the course of completion, show conclusively that these constants (with the proper correction applied for the gravity of the gas being measured) are accurate to a very satisfactory commercial degree, and it is confidently expected that with some little further study and experimenting, particularly along the lines of the mechanical details, the orifice meter will take its place among the most reliable of the various methods of measuring natural gas in large quantities.

[1] Zeit. des Ver. d. Ing., Feb. 23, 1908.

DISCUSSION

P. F. WALKER (written). The experiments made at Joplin go far in establishing the use of the orifice meter as a reliable instrument, at least when employed with conditions essentially similar to those which obtained at that time.

It is well known that for a gas flowing through orifices and nozzles the conditions of flow may be treated by two distinct methods: *first,* considering the relationships existing during the expansion which takes place with the drop in pressure, and *second,* disregarding expansion and treating the gas as a non-expansive fluid. The second method, adopted in the tests described, depends for its absolute accuracy upon the amount of expansion or drop in pressure in proportion to the static pressure in the line on the up-stream side of the orifice. The application of constants derived under one set of conditions must, therefore, be considered with care when conditions are different in marked degree. Because of these facts the corroborative tests referred to in the last paragraph of the paper were undertaken, and the writer has been associated in the work of analyzing the data from these tests.

The question which every engineer will ask, probably, is with reference to this matter of application of factors derived at substantially atmospheric pressure with a drop in pressure of but 3 to 5 in. of water in the orifice, to pipe line conditions where pressures may run close to 300 lb. and the rates of flow may vary through very wide limits, and so cause the differential pressure drop to vary correspondingly.

In the experiments referred to in the last paragraph, a short section (one mile or more) of unused pipe line was cut out and used as a reservoir. From this the natural gas was allowed to flow through orifices arranged much as in the tests with air, the only real difference being that the amount of gas flowing had to be calculated from observations on the drop in pressure in the reservoir. Observations could be, and were, made for a complete range of static pressures up to the values existing in the pipe lines at the time. A corresponding variation in the rates of flow extended the investigation over the

desired range of values of the differential pressure across the orifices.

As first calculated, and this is as far as the work has progressed up to date, it was assumed that Boyle's and Gay Lussac's laws for perfect gases held for the gas in use. This affects three elements, as follows:

a the ratio P_1T_0/P_0T_1 which is introduced to convert the measured volume at the measured pressure P_1 to an equivalent volume at the standard pressure and temperature. Since the temperatures varied so slightly in this work, as is also true for regular operating conditions, no sensible error results from considering only the possible variation of volume ratio from the inverse pressure ratio at a constant temperature.

b the pressure which occurs in the denominator of the radical expression, in conjunction with 14.7 in the numerator, to express the change in density of the gas from standard to existing pressure.

c the volume flowing, Q_0, which is determined by the use of the pressure ratio, as in the first item.

The sum total of these elements is that the left hand side of the equation of flow is affected by the pressure ratio in the unit power and the right hand side is affected in the one-half power.

Dealing with all values as for perfect gases, the value of the coefficient designated in the paper as the "air-coefficient" was calculated for each observation, the value for air being found by reducing backwards by means of the density ratio in order to compare results secured with gas of different densities. In analyzing this mass of data, three main variables had to be considered: static pressure, differential drop in pressure or the dependent quantity hP_1 under the radical, and the ratio of orifice diameter to pipe line diameter. By reducing all to equivalent values of the coefficient for one standard area of orifice, the element of variable size of orifice was eliminated. A total of 1244 values was divided into 12 groups as follows:

Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ over 40
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ from 21 to 40
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ from 11 to 21
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ below 11
A similar set of four for pressures from 50 to 100 lb.
A similar set of four for pressures below 50 lb.

For each of the twelve groups, values of the "air-coefficient" were plotted against ratio of diameters of orifice and pipe, and an averaging curve drawn. From these average curves values of the coefficient were then taken and plotted against values of $(hP_1)^{\frac{1}{2}}$ for each standard orifice, each orifice thus represented fixing a characteristic curve for its particular ratio of diameter to diameter of pipe.

These final curves establish certain laws, or tendencies. For orifices less than 40 per cent of pipe diameter the coefficient is essentially constant. For larger orifices there is a tendency toward lower values for the greater rates of flow or larger values of $(hP_1)^{\frac{1}{2}}$. In general the values tend to become less for the lower static pressures, this tendency being more marked with the orifices which are large in proportion to the pipe. In general, too, the coefficients have values slightly below the corresponding value determined for air in the Joplin tests which form the basis of the paper.

The work is not yet finished, but laboratory experiments are under way to determine the actual *pressure-volume* relationship, or the variations from Boyle's Law, for the natural gas of the Mid-Continental field. When these are completed the results will be re-calculated. In a surprising degree, considering the many variables between quantities and relationships for air near atmospheric pressure and a gas far from the ideal gas on which the laws are based and handled at wide variations in pressure and rate of flow, the values of the coefficients as found in the tests with the gas agree with the values found for air. The variations discovered involve so small a percentage of error, and are themselves subject to correction in such degree, that the air coefficients determined by the author remain standard for their purpose to date.

E. D. LELAND[1] (written) The author has presented a valuable record of results obtained by a reliable method of calibrating orifice discs in connection with the flow of air at low pressures, and the painstaking work tends to increase our confidence in the accuracy of this form of gas measuring device.

It would be an interesting check upon these results and afford valuable additional information, if a series of tests were made in which the flow of gas was reversed, using the same discs and the same holder, but a range of pressures materially higher, of course, making suitable provision for restoring the loss of heat due to expansion. Higher pressures are mentioned because accurate measurement of the flow of gas at comparatively high pressures is an important matter with large gas companies and has been receiving their careful attention.

TABLE 5 COMPARISON OF ACCURACY OF METERS

Cu. Ft. by Venturi	Cu. Ft. by Orifice	Cu. Ft. by Pitot	Cu. Ft. by Proportional Meter
Six-hour Test of Natural Gas at Average Pressure of 130 Lb.			
3,885,000	3,908,000	3,846,000	3,958,000
Eight-hour Test of Natural Gas at Average Pressure of 124 Lb.			
5,448,000	5,416,000	5,351,000	5,393,000

Volumes given are at 10 oz. and 62 deg. fahr.

The author's conclusion that the orifice meter will take its place among the most reliable of the various methods of measuring natural gas in large quantities is in harmony with results obtained by F. W. Schell[2] from recent tests near Blacksville, W. Va. In August, 1915, Mr. Schell conducted a long series of tests with special reference to the accuracy of the venturi meter, but including various other measuring devices, and the results which are given in Table 5, include the performance of the orifice meter at a pressure of about 130 lb.

In these tests a 12 in. x 6 in. orifice meter, a 12 in. Wylie proportional meter, and 5 in. and 3 in. calibrated pitot tubes were connected in series with the 12 in. x 6 in. standard venturi meter in use at that point. Before using, the proportional meter was tested by means of a standard test flowmeter and found to be accurate and in good condition.

The close agreement of these various devices was very satisfactory and indicated that the gas was being measured with a degree of accuracy well within the requirements of the Pennsylvania State Public Utilities Commission.

[1] Supt. Compressing Stations, Philadelphia Co., Pittsburgh, Pa.
[2] Mechanical Engineer, Philadelphia Co.

H. B. Bernard (written). I wish to ask the author whether he has any trouble due to erosion of the orifice on account of the small edge employed. The more common form of orifice is of $\frac{1}{8}$ in. stock, with a flat edge for the entire thickness of the plate. Some of this type have been in use since 1911, and to date have shown no appreciable increase in diameter.

No mention is made in the paper of what size holes are used in making connections. T. R. Weymouth, Mem.Am.Soc. M.E., has found, by numerous investigations that a saddle used over a $\frac{1}{8}$-in. drilled hole gives the best results.

I cannot agree with the author if he believes the distant connections more efficient than the flange connections. With the latter the coefficient of flow—ratio of diameters curve—is much flatter and minimizes an error in not having the exact internal diameter of the pipe. Undoubtedly eddying occurs at the orifice, but I know of no installations, not made near a compressor, where the accuracy of measurement is impaired.

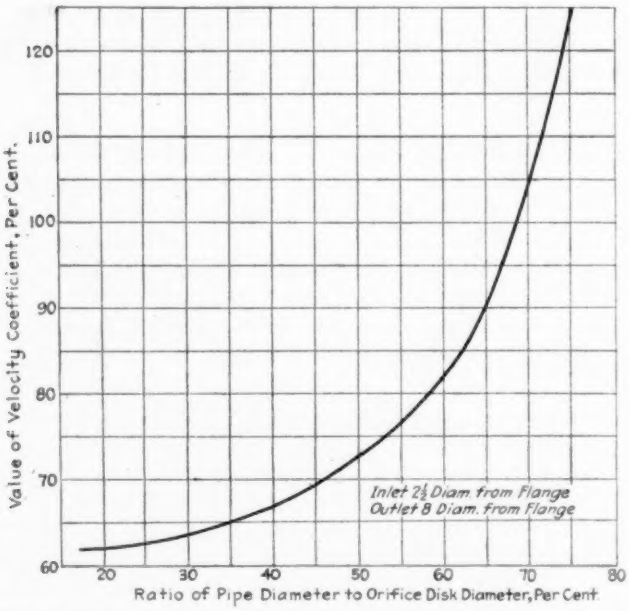

Fig. 3 Velocity Coefficients of Orifice Meter Discs from Tests by W. T. Young

Of course, any meter will invariably read high, if installed on the suction or discharge line close to the compressor, even though deadeners be used in the gage line. I doubt if the connections employed by Mr. Hickstein would eliminate this.

In a test by W. T. Young, at the Buffalo Test Station in June, 1914, an effort was made to determine the recovery of differential in an orifice meter. A Foxboro type flat edge orifice was used. Flange connections and connections as described by the author, giving a maximum differential and a minimum differential respectively, were compared. The results showed a recovery close to 17 per cent for 1.2 in. differential at the flange, under 36.72 lb. per sq. in. absolute pressure on the low side, and increasing at the rate of 0.4 per cent per 10 in. increase in differential under constant pressure. It was also shown that there was a slight drop between the inlet points, the percentage decreasing as the differential increased.

I have some data from tests performed by Mr. Young at the Buffalo Test Station in June, 1914, on Mr. Hickstein's plates, in which distant connections were used, and the results vary considerably from those obtained by the author. The tests were conducted at practically constant pressure, ranging from 30 lb. gage on some plates to 50 lb. on others, with increasing differential from zero to 17 in. of water as maximum on the largest plate, and from zero to 27 in. on the smallest plate. The efficiency curve, Fig. 3, had a value of 0.62 at 0.20 ratio of diameters; the curve crossed the author's curve at 0.63 ratio of diameters, and at 0.75 ratio it had a value of 1.234. The gas was measured by pitot tubes and flange connection orifices, which had been calibrated previously against gas holders by natural gas.

In the comparison of the author's with the Charlottenburg tests, I cannot understand why the difference in pipe sizes should be taken into account, inasmuch as the Charlottenburg curve falls outside the author's curve for the 10-in. line for the greater portion of its distance.

Considerable work on the subject of flow measurement by the orifice method has been done by T. R. Weymouth and by the Foxboro Company, and it seems that in no great length of time the orifice meter will be adopted by artificial gas companies as station meters.

G. T. Voorhees said that some years ago he had occasion to make a number of observations on the flow of gases and liquids through very tiny orifices and at very high pressure. As he remembered, the orifices were made in a $\frac{1}{8}$ inch plate and some of them were drilled as small as 1/100 of an inch. The pipe used was about a $\frac{3}{8}$ inch pipe, so that the relation of the orifice to the pipe was large. He found that the coefficient of this discharge was between 60 and 80 per cent.

He asked whether the coefficient of discharge should decrease with the size of the orifice.

J. T. Wilkin said that in the manufacture of rotary blowers and gas exhausters there comes up quite often the question of efficiency tests necessitating the accurate measurement of the air and gases. The paper shows that this measurement is a very delicate thing to make correctly owing to temperatures, water vapors and other conditions.

He recited an instance in which results of tests on a large gas holder had been influenced very much by the sun shining on the holder.

He hoped there would be developed some standardized method of making tests on the efficiency of machines that would be acceptable. He thought the paper was of interest in the development of such a method.

Carl C. Thomas said that the difficulty of making accurate holder tests is very great. When the gas comes up through the water and is collected in a large vessel the changes in volume due to humidity, and the changes in humidity resulting from changes of temperature, necessitate very considerable corrections. He had had quite a good deal to do with holder tests and he believed that the only accurate way to conduct these tests was to wait until the gas inside the holder had attained as nearly as possible a constant temperature. This conditon does not occur in the day time except on some very cloudy days, and then the results are not so good as at night. The best results he had seen were obtained between 11 p. m. and 4 a. m. He would have some doubt about computing the contents of the holder by using some function of the temperature at the top of the holder and that at the bottom.

With regard to the change of coefficients with different sized orifices, that depends upon the amount of gas or the velocity of gas passing through. It is fairly well established that the coefficient does change as some function of the velocity of the gas flowing through the orifice, but accurate experimental data are not yet available showing over what range orifice measurements are reliable. The condition of the orifice has a great deal to do with the matter. He has been interested in results

obtained on natural gas lines connected with the City of Los Angeles, where questions had arisen which were evidently dependent upon the maintenance of orifices in good condition. The velocity flow is very high,—sand is carried along with gas, —and other influences, such as corrosion, deposit, etc., affect the readings.

The bevel of the orifice has a very distinct effect upon the quantity of gas which will flow through it, so that some standard has to be arrived at and maintained in order to insure continuous reliability.

S. A. Reeve said that he had made considerable use of a holder for commercial tests of gas flow and had found that entirely satisfactory conditions could be obtained by using a covered holder, and by keeping a constant flow of water circulating over the bell of the holder from the tank. The air was not pumped in through the water but through a dry pipe so that the humidity did not vary considerably, and the temperature in the building, through the action of the water circulation, seemed to have been kept constant. The holder was about 30,000 cu. ft. capacity.

Prof. A. M. Greene, Jr., asked whether with a small differential change in pressure it is not necessary to consider the pressure on both sides of the orifice or some function of that pressure.

The Author. As Mr. Bernard states, one type of meter disc is made of $\frac{1}{8}$ in. stock, with a flat edge for the entire thickness of the plate. Another type, on the other hand, is about $1\frac{1}{2}$ in. thick, with a flat-edge orifice. What is probably the oldest type in use in the natural gas industry is about $\frac{5}{8}$ in. thick, with the orifice edge similar to those tested by the author, i.e., flat for a very short distance, and then beveled. These last-mentioned discs are case-hardened before being put in line. As was brought out in the discussion, the fact is unfortunate that no one type of orifice has been standardized.

Mr. Bernard questions if the size of the orifice increases after disc is put in line. Several months ago, this question was well answered by a micrometer measurement of the diameter of an 8-in. x 5-in. disc through which possibly fifteen billion cubic feet (twenty million a day for about twenty months) of natural gas at between 250 and 400 lb. line pressure had been passed. No appreciable increase in diameter was found, and the author feels that there is little ground for the apparently common misapprehension that the orifice diameter increases when a disc is put in use. One disc has come to the author's attention, with a part of the edge (possibly one quarter the size of a finger nail) chipped out. This was a case-hardened disc; and the presumption is that the damage was caused by a rock traveling with the gas at high velocity. It is important, however, to examine the disc at a meter station occasionally, as the effective area of the orifice may be altered by some object lodging in front of it.

The connections used were ordinary $\frac{1}{4}$-in. nipples screwed into the pipe, care being taken that the nipple did not extend further than the inside of the pipe. This method of connecting is very simple, and proved as satisfactory as more complicated methods. A possible explanation of Mr. Bernard's criticism of the fact that the Charlottenburg curve falls outside (below) the 10-in. Joplin curve may be found in the error he mentions involved in not using the exact size of pipe when d/D was calculated.

A long discussion of the distant connections versus flange connections question is hardly in place here. The advantage of having a flat curve "to minimize an error in not having the exact internal diameter of the pipe" does not enter, unless coefficients found for one size of pipe-line are arbitrarily used on some other size of line.

As Professor Walker mentioned, corroborative tests were made before the Joplin constants, found for air at atmospheric pressure and with low differentials, were used for high pressure gas at varying differentials. Very probably more will be said about these tests in a paper to be presented by F. P. Fisher at the coming New Orleans meeting of the Society. The results of Professor Walker's study of these tests are most interesting. His handling of the large number of variables that entered into the tests was a revelation to the engineers associated with him in the work.

Mr. Schell's success, as reported by Mr. Leland, in getting four types of meters to run so closely together, is unusual. It is an indication of the improved methods and ideals now coming in vogue in gas measurement. The statement that it is impossible to get two gas meters in series to read alike is still frequently heard, but there are some engineers nowadays who know better.

The author was interested in Professor Thomas' comment on his experiences with holder tests. In the Joplin tests, it is worthy of note here, the air did not pass through the water, either in entering or in leaving the holder, as several of the contributors to the discussion appear to have in mind. The fact that Professor Thomas also found it advisable to conduct the tests at night is significant. The author, when he described his method of arriving at an approximate temperature of the air inside the holder, did not mean to establish a hard and fast rule that this temperature for *any* holder could be found as a function of two thermometer readings. All he wanted to show was that for the particular holder in question, and especially during the hours at which tests were made, such a function of two other temperatures would give the value required.

The question of the variation of a disc's coefficient with varying pressures and differentials is mentioned by Professor Thomas. Professor Walker's contribution mentions some tests made to study these changes. Apparently, for constant pressure, a variation of the differential between commercial limits (say 5 to 100 in. of water) has no appreciable effect. The effect of varying the pressure between the limits found in pipelines has a slight effect (not more than one per cent, between 0 and 250 lb.). Sometimes this is taken care of by the use of a "sliding" coefficient for the orifice disc.

Professor Greene asks if it is not necessary to consider the pressure on both sides of the orifice, or some function of that pressure. This question is often asked by engineers who expect to see, as a factor in the equation, a square root of the difference of two squares of pressures. However, for all purposes, where the differential reading is not greatly in excess of the values found in practice, the $\sqrt{hP_1}$ is practically equal to Constant times $\sqrt{P_1^2 - P_2^2}$, where h = differential drop in pressure, P_1 = inlet pressure (absolute) and P_2 = outlet pressure (absolute), and the equation involving the factor, $\sqrt{hP_1}$, is in a more convenient form.

In some orifice meter installations, the "static" pressure reading is taken on the outlet side of the meter. This seems more or less a matter of preference, with the restriction, of course, that the same method of connecting must be used as when the disc was originally calibrated.

Mr. Voorhees' inquiry is as to whether the coefficient of discharge should decrease with the diameter of orifice. Such is the case, not only with the discs of the type tested at Joplin,

but with orifice meter discs of every type with which the author is familiar. This is not true, however, of an orifice at the end of a pipe-line, or inserted at the end of a drum, and discharging into the atmosphere. With this type of orifice, an increase of the orifice diameter causes a decrease in the coefficient.

The discussion clearly indicates the increased interest in the subject of gas measurement by orifices. That the number of commercial orifice meter installations now in use for measuring natural gas is far in excess of one thousand is believed to be a conservative estimate. Since the paper was written just about a year ago, at least one additional type of orifice meter has been placed on the market, and there is good reason to expect that several more are to follow.

Probably the most important mechanical development of the past year has been the perfecting of a recording gage especially suited to orifice meter use. This is a compound pressure and differential-pressure gage, i.e., two records are made on the same chart by two pens using different colored inks, and marking over the same scale. This means that just half as many charts have to be handled each day, and also makes possible simplified pipe connections. A "safety" or blow-over device as an integral part of the gage—one that really prevents damage to the gage on excessive differential readings—is a most welcome innovation. This gage is of the mercury float type—the principle towards which the author has always been partial. Altogether, the installation of some sixty or seventy of these gages has gone a long way towards solving his gage troubles of the last three years.

A paper by F. G. Keyes in the Journal of the A. S. R. E., January, 1916, gives equations for ammonia based on new experimental material. The constants of the equation of state were determined from data in the region of high temperatures, and then by means of the equation, comparisons were made by calculating the volumes of the measured pressures and temperatures for the data at large concentrations.

There is some discrepancy between various published coefficients for orifices. Probably the sharpness of the edge has considerable influence. Since, apart from this, the coefficient for an orifice varies with the pressure, the best plan for the measurement of air-flow by means of this type is evidently to employ a short convergent nozzle with a rounded entrance, and to adopt a coefficient of 0.98. Capt. T. B. Morley, *Proc. Inst. Mech. E.* (meeting, January 21, 1916.)

"Ignition by compression," so generally and superficially accepted as the fundamental principle underlying Dr. Diesel's invention, was, as a matter of fact, merely a natural corollary, and was not even claimed by him as his original conception, although typical of the engines that bear his name and successfully employed in them alone. Dr. Diesel's great aim was a closer realization of the theoretical efficiency of the Carnot cycle than attainable by steam engines or internal combustion engines of the ordinary types. And although his aspirations were crowned with only partial success, it is scarcely to be doubted that they created a heat engine that has the highest efficiency that will ever be attained with fuel. Max Rotter, Mem. Am. Soc. M. E., *International Engineering Congress, 1915.*

ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN

BY JAMES E. BOYD, COLUMBUS, O.

Member of the Society

THIS investigation was undertaken at the suggestion of Ralph D. Mershon,[1] Mem.Am.Soc.M.E., who expressed the belief that exact knowledge of the form of the stress-strain diagrams of clay products in tension and compression would make possible the design of insulators of greater mechanical strength and more definite factor of safety.

TEST PIECES

The test pieces were obtained from the General Electric Co. and the Keasbey Stoneware Works. Pieces used in some of the later tests were made at the Ohio State University.

Fig. 1 shows the shape and size of the test pieces furnished by the General Electric Co. and the Keasbey Stoneware Works. The porcelain pieces from the former were all of one composition, while the stoneware pieces from the latter were of five different types, designated by the manufacturer as W. M., 132, 2x4, 53, and 3 respectively.

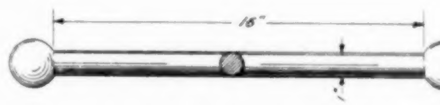

Fig. 1 Round Test Piece

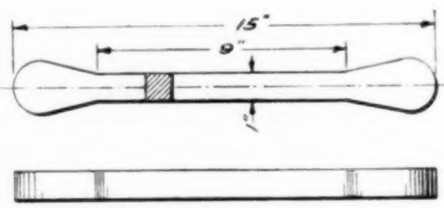

Fig. 2 Rectangular Test Piece

Fig. 2 shows the form of the pieces made at the University by forcing the clay through a rectangular die, and then carefully cutting to the desired form in the hope of eliminating internal stresses.

All measurements of deformation were made by means of a lever extensometer, with arms approximately 0.25 in. and 12.5 in. in length respectively. Each instrument is calibrated by using it to measure the pitch of a micrometer screw, and the longer arm is adjusted to make the magnification 50.

The micrometers are supported by a pair of wooden bars clamped to the test piece about 2 in. above the clamp supporting the levers.

To avoid error when the load is eccentric, care was taken to have the two levers at equal distances from the test piece, and also to have the knife edges and the axis of the test piece in the same vertical plane.

Contact between clamps supporting extensometer levers and test pieces was made through soft solder.

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[1] Member of Research Committee and Chairman of Sub-Committee on Materials of Electrical Engineering.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

GRIPS FOR TENSION TESTS

The first grip tried consisted of a 2-in. pipe coupling with a reducer bushing at the end. The bushing was cut in halves so that it could be fitted around the test piece below the head and then screwed into place. One of these grips is shown in Fig. 5 at the lower end of the vertical rod at the left. Soft material, usually leather, was placed between the bushing and the head of the test piece. A rod with a spherical head was passed through a second bushing (not shown) at the other end of the coupling, giving the effect of a ball and socket joint.

Upon using this grip in tension tests, the extensometer readings revealed considerable eccentricity of loading due to lack of perfect symmetry in the heads of the test pieces and want of uniformity in the soft material against which the heads pressed. This eccentricity might have been eliminated by supporting each grip on pairs of adjustable knife edges at right angles, but on account of the inconvenience and expense this arrangement was not adopted.

Fig. 3 shows another form of grip used for most of the tension tests of the cylindrical pieces. This consists of two steel plates held together by three bolts. A conical depression in each plate holds some soft material—lead, leather, or rubber—which, in turn, grips the head of the test piece. The upper bolt passes through the pulling rod *B*, forming a hinge connection. The rod *B* may be moved along the bolt to adjust slightly and a further adjustment may be made by loosening

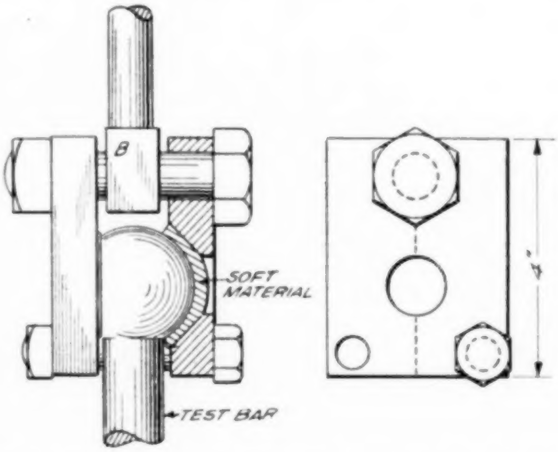


Fig. 3 Grip Used in Tension Tests of Round Rods

the bolts and changing the alignment of the test piece and grip. With this arrangement it is practicable to so reduce the eccentricity that the elongations as shown by the two micrometers become nearly equal. There still remains, of course, the possibility of eccentricity at right angles to the plane of the instruments, which may only be determined by means of a third lever.

With this grip it was found that practically all the pieces still broke at the head. (Four of these shown in Fig. 5 illustrate the characteristic failure.) As it was thought that this failure might be caused by too abrupt change of section, the form of test piece shown in Fig. 2 was developed. The clamp for this piece is shown in Figs. 4 and 5. Sheet lead was first tried as the soft material to distribute the stress. With a bearing area of about 4 sq. in. the lead failed, principally by shear, when the pull was 2900 lb. Leather failed at 2400 lb. It is evident that the slope of the head of this form of test piece is too small for these materials, unless the ratio of the bearing area to the cross section of the stem is considerably increased. Copper and aluminum were found too hard, causing the porcelain to chip locally.

These test pieces all failed at the head, but at some distance above the stem. Fig. 5 shows the head and part of the stem of one piece with a characteristic failure. Sometimes the fracture was a little below the lower edge of the bearing area, sometimes a little above.

Two explanations are suggested for this method of failure. One is that the stress is concentrated in the outer fibers of the head and is really of greater intensity here than in the smaller section of the stem, where it has become uniformly distributed. As stress is transmitted from the outer fibers inward in the form of shear, the shearing strength and modulus become factors. The other explanation is that the tensile stress developed as a result of the transverse compressive stress makes the total

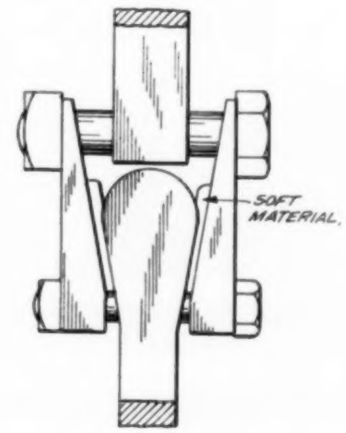


Fig. 4 Grip Used in Tension Tests of Rectangular Rods

stress at the section of failure much greater than at the stem. Assuming that the unit compressive stress is 10,000 lb. per sq. in. and that Poisson's ratio is $\frac{1}{4}$, the compression alone develops a tensile stress of 2500 lb. When this is added to a direct tensile stress of perhaps 2000 lb. per sq. in., we get a stress in the head of 4500 lb. per sq. in., which easily accounts for the failure. It is probable that both of the above factors are present and that, combined with more or less eccentricity of loading, they each contribute to the failure.

TABLE 1 TENSION TEST OF STONEWARE 53 I

Area, 0.77 sq. in. Feb. 7, 1913.
Gaged length, 12.57 in.

Load, in Lb.		Micrometer Reading			Elongation in 0.00001 In.		
Total	Per Sq. In.	Left	Right	Sum	From 10 lb.	From No Load	Unit
8	10	503	384	887	0	2	....
154	200	526	404	930	43	45	3.57
308	400	558	415	973	86	88	7.00
462	600	567	448	1015	128	130	10.34
616	800	588	467	1055	168	170	13.52
770	1000	609	489	1098	211	213	16.96
924	1200	635	501	1136	249	251	19.97
1001	1300	648	509	1157	270	272	21.64
1078	1400	665	521	1186	299	301	23.95
1155*	1500	...	...	...	...	...	....

* Broke before reading could be taken.

RESULTS OF TENSION TESTS

Table 1 gives the results of one tension test. In this test several sets of readings were made with loads up to 800 lb. per sq. in., in order to adjust the grips to reduce eccentricity. In these preliminary runs several readings were taken at each load. As these showed little variation, a single reading only was taken at each load for the last set which is given in the table.

The third column of micrometer readings is the sum of the readings of the two instruments. The micrometers read in 0.001 in., and the lever magnification is 50, so that differences

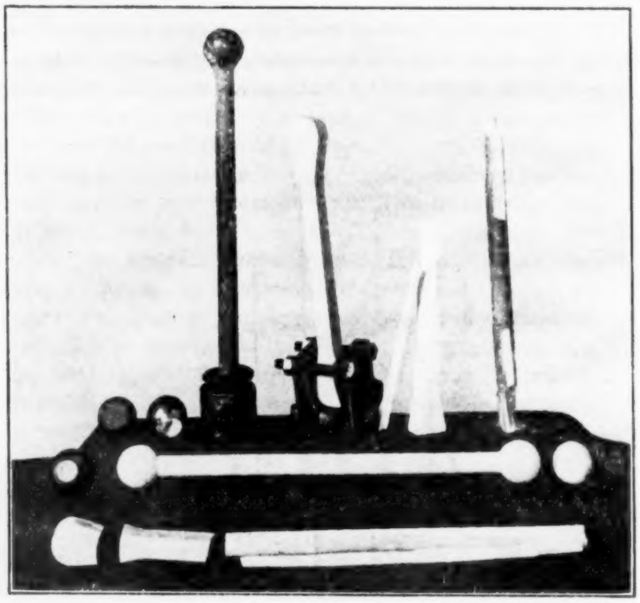


FIG. 5 TEST PIECES, SHOWING GRIPS AND TYPICAL FRACTURES

between successive readings of either micrometer represent 0.00002 in., and differences between figures in the column of sums are in 0.00001 in.

The results of this test are shown graphically by the lower curve of Fig. 6. The diagram is practically straight up to 1300 lb. per sq. in. The broken line from 1400 to 1500 lb. per sq. in. is intended to show that it carried the load represented by the ordinate but that no deformation reading was secured above 1400 lb. per sq. in. The modulus of elasticity, calculated from the single reading at 1000 lb. per sq. in., is

$$E = \frac{1000}{0.000170} = 5{,}900{,}000$$

Besides stoneware 53 I, Fig. 6 represents three other tension tests, porcelain I, stoneware 132 III and stoneware 2x4 I. In each case the particular tension test represented is the one showing the highest ultimate strength, as may be seen from Table 2.

It will be noticed that each of these diagrams, except stoneware 53 I, is practically a straight line giving no definite indication of a true elastic limit. The double curve in the porcelain diagram is probably due to temperature changes, as there was considerable draft on the apparatus at times during this run.

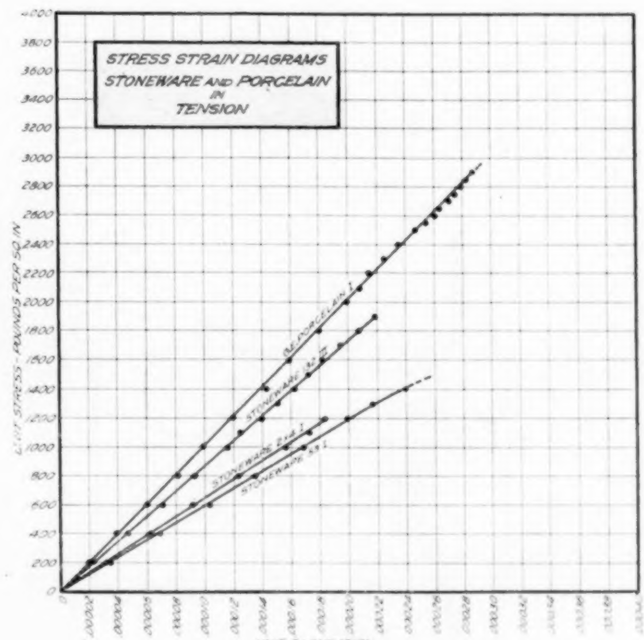


FIG. 6 STRESS-STRAIN DIAGRAMS, PORCELAIN AND STONEWARE

TABLE 2 TENSION TESTS OF PORCELAIN

Lb. per Sq. In.	Unit Elongation In 0.00001 In.					Modulus of Elasticity
	I	II	III	IV	Average	
200	2.06	1.83	1.90	1.96	1.94	10,310,000
400	3.96	3.74	3.96	4.16	3.95	10,130,000
600	6.10	5.48	5.86	6.19	5.91	10,150,000
800	8.24	7.24	7.69	8.47	7.91	10,110,000
1000	9.90	9.07	9.91	10.35	9.81	10,190,000
1200	11.97	10.75	11.81	12.23	11.69	10,260,000
1400	14.34	12.89	13.79	14.43	13.86	10,100,000
1600	15.93	14.57	16.24	16.39	15.78	10,140,000
1800	18.07	16.72	17.75	18.74	17.82	10,100,000
2000	19.97	18.39	19.89	20.71	19.74	10,130,000
2100	20.76	Broke	.....	.....		
2200	21.39		21.31	Broke *		
2300	22.58		.....			
2400	23.53		23.30			
2500	24.64		24.72			
2600	26.16		25.44			
2700	27.10		26.70			
2800	27.97		27.89			
2900	28.76		28.68			
2950	Broke		.....			
3000			Broke			

* Broke at extensometer clamp at point where solder was crushed so that brass was in contact with porcelain.

TABLE 3 COMPRESSION TESTS OF PORCELAIN I AND STONEWARE W.M.II

Lb. per Sq. In.	Unit Compression In 0.00001 In.		Modulus of Elasticity	
	Porcelain	Stoneware	Porcelain	Stoneware
1000	9.4	11.2	10,640,000	8,930,000
11000	104.8	129.8	10,500,000	8,470,000
12000	116.0	144 7	10,340,000	8,220,000
13000	125.7	158.2	10,340,000	8,220,000
14000	135.3	174.0	10,350,000	8,050,000
15000	145.6	189.1	10,300,000	7,930,000
15500	.....	196.5		
16000	155.4	Levers }		
17000	166.4	removed }		
18000	177.3	Failed at 21500		
19000	Failed	lb. per sq. in.		

Table 2 gives the results of tension tests of four rods of General Electric porcelain.

COMPRESSION TESTS

For compression tests rods were cut off to a length of 16 in., and 12 in. was used as the gage length. Sheet lead was placed between the ends of the test piece and the plates of the testing machine. A preliminary test was made on a rod of stoneware 3. This rod, 8 in. in length, failed suddenly with a sharp noise under a load of 15,000 lb. per sq. in. It flew into many small fragments with the principal planes of fracture parallel to its length.

Measurement of elongation was made on two pieces, both of which failed by splitting lengthwise. Both rods are shown in Fig. 5. The porcelain rod, in a horizontal position in the front of the picture, has a single piece split off for almost its entire length. The split-off piece extends from the top of the rod to the position of the lower extensometer clamp. The other rod of stoneware W.M. shown standing at the right of Fig. 5 failed at the ends. Table 3 gives part of the results of the compression tests of these two pieces. Fig. 7 gives the diagram for Table 3. The porcelain curve varies little from a straight line; there is a slight change of slope at 7000 lb. per sq. in. which may indicate a true elastic limit. The stoneware curve bends slightly at 3000 lb. and shows considerable change of slope at 11,000 lb. per sq. in.

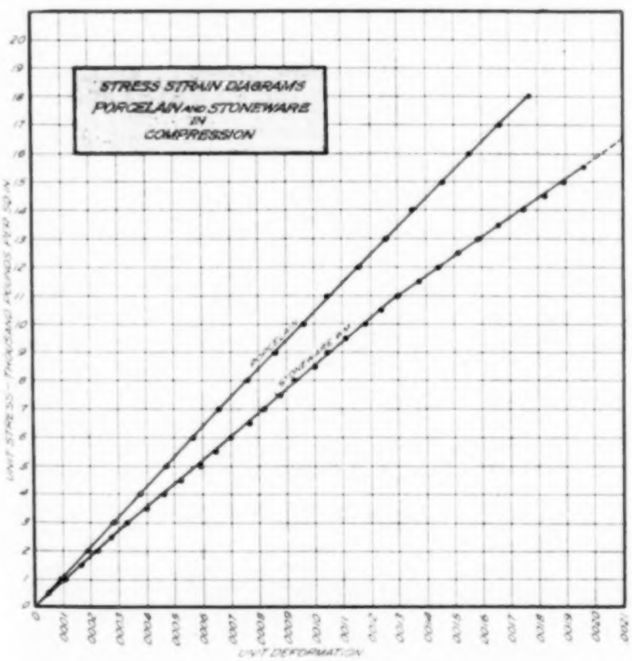


FIG. 7 STRESS-STRAIN DIAGRAMS, PORCELAIN AND STONEWARE

BENDING TESTS

Fig. 8 shows the arrangement of the apparatus for bending tests. The test bar is supported at two points B and B' and loaded equally at two symmetrical points A and A'. The extensometer lever is carried on a wooden beam, so mounted that it practically connects two points on the neutral surface of the test bar at equal distances c outside the load points A and A'. The connection between test bar and beam is made through two steel stirrups, of which the right one, D, is rigidly fastened to the beam and the left one, E, is joined through a pair of cone pivots. Brass clamps gripping the test bar are connected to the stirrups through cone pivots. This arrangement keeps the wooden beam parallel to the line joining the upper pivots and at a constant distance therefrom. At a point midway between the supports a third clamp is attached to the test bar and connected to the extensometer lever by a short steel rod. As the middle of the test bar rises when the load is applied, the test may be carried to failure of the piece without danger to the apparatus. The movement of the longer

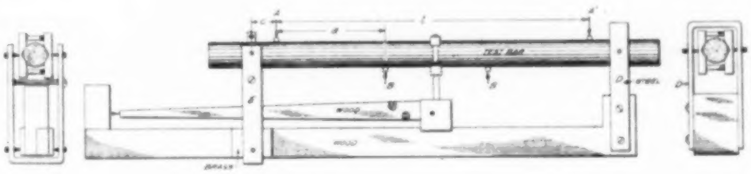


FIG. 8 APPARATUS ARRANGED FOR BENDING TESTS

arm of the lever is measured by a micrometer attached to the wooden beam.

With this apparatus, the error due to temperature change is very small, and the curves obtained are more satisfactory than those of the tension tests.

In most of the tests the distance l between the loads was 12.6 in., and the distance a from A to B and from A' to B' was 4.2 in., so that the deflection of the middle of the bar above the line joining A and A' is the same as that of a beam supported at the ends and loaded at the third points. This deflection is

$$\frac{23\, P\, l^3}{1296\, E\, I}$$

where P is the total load, and I the moment of inertia of the cross-section. The additional deflection at a distance c from A is the product of the length c multiplied by the slope of the tangent to the bar at A.

Table 4 gives the results of one test of a stonewood rod. The stress in the outer fibers has been calculated in the usual way. In order to draw curves which may be compared with the tension and compression diagrams, the unit deformation in the outer fibers for that portion of the bar between the supports is given in the fourth column.

Fig. 9 gives the diagram for Table 4, together with those of two other kinds of stoneware and one of porcelain—the same materials which are shown in tension in Fig. 6. It will be noted that the diagram of porcelain is straight while those of stoneware 132 and 53 bend a little. The diagram of stoneware 2x4 seems to be straight when drawn to this scale, but

TABLE 4 BENDING TEST OF STONEWARE 2x4 1

Diameter, 0.945 in. to 0.955 in. — Dec. 5, 1913.
Average diameter, 0.949 in.
l = 12.6 in.; a = 4.2 in.; c = 1.2 in.

Load in Lb., P	Deflection in In., y	Unit Stress in Outer Fibers	Unit Deformation in Outer Fibers 0.00001 In.	Modulus of Elasticity
12	0.00208	300	4.5	6,670,000
22	0.00382	551	8.3	6,660,000
32	0.00558	801	12.1	6,650,000
42	0.00728	1051	15.7	6,680,000
52	0.00904	1302	19.5	6,660,000
62	0.01080	1552	23.4	6,640,000
72	0.01256	1802	27.2	6,630,000
82	0.01442	2052	31.2	6,580,000
92	0.01618	2303	35.0	6,580,000
102	0.01806	2553	39.0	6,540,000

the figures of Table 4 show that there is a slight curvature. Since only the outer fibers in the middle third of the test bar reach the calculated stress, it is evident that the diagram from the bending test should be nearer a straight line than the corresponding tension curve.

COMPARISON OF TESTS

Fig. 10 gives compression, bending, and tension diagrams for G. E. porcelain. It will be seen that the compression curve for porcelain I has the same slope as the bending curve of porcelain II, while the tension curve for II has a little higher and the tension curve for I a little lower slope. Considering the variation in the tension tests as shown by Table 2, together with the fact that the curve for bending depends upon tension and compression jointly, it is probable that the modulus of elasticity in tension differs little, if any, from the modulus in compression.

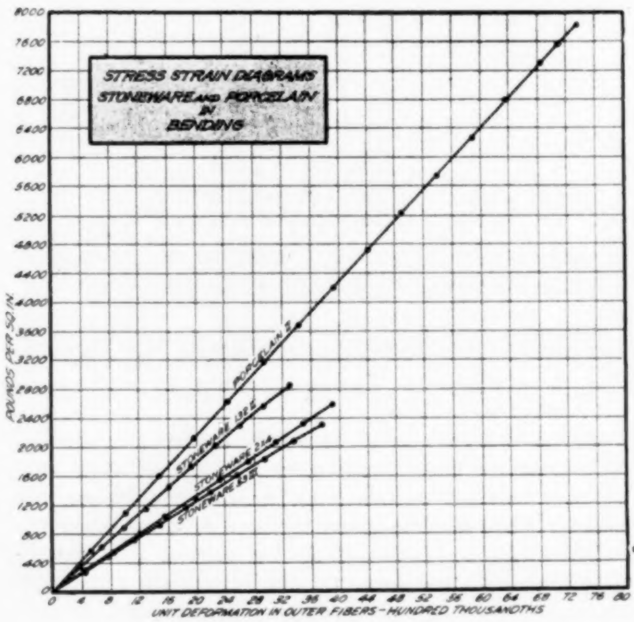


FIG. 9 STRESS-STRAIN DIAGRAMS, BENDING TESTS

If the bending curve for this porcelain be, as it seems, a straight line with the same slope as the compression curve, it follows that the ultimate tensile stress is the same as the modulus of rupture, or 7800 lb. per sq. in. If the bending curve deviates a little from a straight line, but not enough to show without greater refinement of measurement, there may be considerable deviation in the upper portion of the tension curve so that the real stress at rupture may be somewhat below 7800 lb. per sq. in. In any case, it is evident that the tension tests did not develop the full tensile strength.

Table 5 gives a summary of all the tests in which a complete series of readings were taken. The third column of this table gives the unit deformation at the unit stress of 1000 lb. per sq. in. Where no reading was taken at this load, the deformation has been computed by interpolation from the two nearest readings. The fourth column gives the modulus of elasticity calculated from the stress of 1000 lb. and the deformation of the third column. The fifth and sixth columns give the last unit deformation read and the corresponding unit stress. The modulus of elasticity calculated from these figures, or from the difference between them and the corresponding deformation and stresses at 1000 lb., will show whether the curve of the material deviates from a straight line.

CONCLUSIONS

From the results of these tests, the following conclusions may be drawn:

a The modulus of elasticity of stoneware and porcelain is practically the same in tension and compression. Its value may be obtained conveniently by a bending test.

b The modulus of elasticity of porcelain is about 10,000,000. The modulus of stoneware ranges from 6,000,000 to 9,000,000, depending on the material.

TABLE 5 SUMMARY OF TESTS OF STONEWARE AND PORCELAIN

Test Bar		Kind of Load	Unit Deformation at 1000 Lb. per Sq. In.	Modulus of Elasticity	Last Unit Deformation Read	Unit Stress	
						At Last Reading	At Failure
Porcelain							
G. E.	I	tens.	0.000099	10,100,000	0.000288	2900	2950
G. E.	II	tens.	91	11,000,000	184	2000	2100
G. E.	III	tens.	99	10,100,000	287	2900	3000
G. E.	IV	tens.	103	9,700,000	207	2000	2200
G. E.	I	comp.	0.000094	10,600,000	0.001773	18000	19000
G. E.	II	bend.	92	10,800,000	736	7822	7822
G. E.	III	bend.	97	10,300,000	646	6448	6448
Ohio S. U	III	tens.	0.000116	8,600,000	0.000330	2600	2700
Ohio S. U.	IV	tens.	121	8,300,000	271	2200	2400
Ohio S. U.	IX	tens.	108	9,200,000	329	2800	2900
Stoneware							
53	I	tens.	0.000170	5,900,000	0.000240	1400	1500
53	II	tens.	166	6,000,000	231	1400	1500
53	I	bend.	160	6,250,000	441	2666	2666
53	II	bend.	158	6,300,000	376	2291	2291 +
2x4	I	tens.	0.000157	6,400,000	0.000184	1200	1200 +
2x4	II	tens.	158	6,300,000	178	1100	1200
2x4	III	tens.	155	6,450,000	155	1000	1100
2x4	I	bend.	150	6,700,000	390	2553	2553
W. M.	I	tens.	0.000118	8,500,000	0.000269	2150	2200
W. M.	II	tens.	105	9,500,000	201	1800	1900
W. M.	III	tens.	109	9,200,000	191	1800	1900
W. M.	I	bend.	112	8,900,000	395	3444	3444
W. M.	II	comp.	112	8,900,000	1965	15500	21500
3	I	tens.	0.000173	5,800,000	0.000244	1400	1400 +
3	II	tens.	177	5,650,000	177	1000	1100
3	III	tens.	161	6,200,000	250	1500	1600
3	II	bend.	169	5,900,000	384	2231	2231
132	I	tens.	0.000113	8,900,000	0.000181	1600	1650
132	II	tens.	127	7,900,000	152	1200	1250
132	III	tens.	116	8,600,000	219	1900	1900
132	II	bend.	112	8,900,000	328	2848	2848

c The compressive strength of porcelain and high grade stoneware in a column 16 in. long and 1 in. in diameter is about 20,000 lb. per sq. in. The stress-strain diagram is practically straight up to 7000 lb. per sq. in.

d The tensile strength of porcelain is above 3000 lb. per sq. in. The diagram is a straight line up to this stress. The tensile strength of stoneware ranges from above 1100 to above 2200 lb. per sq. in. The stoneware of the greater modulus has the greater strength.

These tests failed to develop the full tensile strength of the material. Judging from the bending tests and the form of the diagrams, it is probable that the real tensile strength is about twice as great as the figures here given.

DISCUSSION

RALPH D. MERSHON (written). In suggesting to Professor Boyd the investigation he has so excellently carried out on the mechanical properties of ceramic materials, I had in mind more than the bearing of the subject upon the matter of insulation. For a long time it has seemed to me there were uses for ceramic materials where they are not now used, presumably because of the lack of information relative to their mechanical properties. One important possibility is that of the employment of clay pipes in many places where iron or steel ones are now used, especially underground. Of course such pipes are regularly used for sewers and drains, and I believe that to some small extent they have been employed for low pressure gas mains. But their use seems to have been confined to cases where the internal pressure was little or nothing. It would seem that their durability might be availed of in uses involving considerable internal pressures, if more were

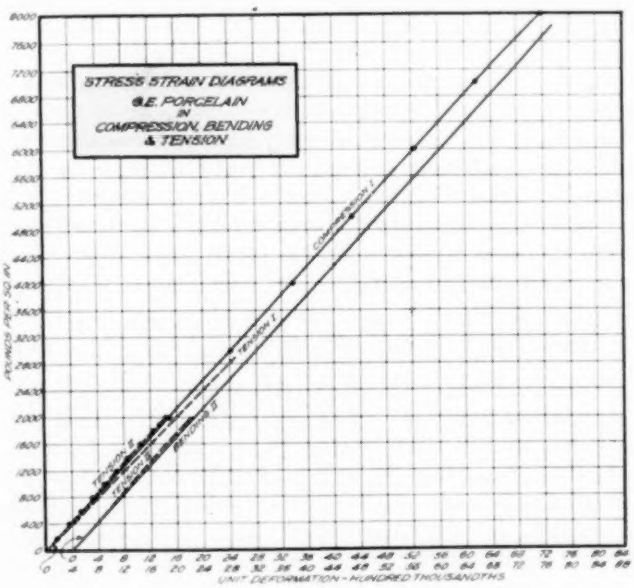


FIG. 10 STRESS-STRAIN DIAGRAMS FOR PORCELAIN

known of the characteristics and the possible uniformity of the material composing them.

So far as I know, this work of the author is the first systematic investigation ever made of the mechanical properties of ceramic materials. It is to be hoped that it is a forerunner of further work along this line, both by Professor Boyd and others, and that we may have, before long, the results of investigations as to the influence of various mixtures, methods of working, and degrees of firing, upon the mechanical properties of ceramic materials, and upon the uniformity with which products composed of such materials can be produced.

R. C. CARPENTER (written). The investigation described by Professor Boyd is the first that I have been able to learn about which gives information of the strength of stoneware and porcelain under conditions of use. The information given by the paper is of great value in all the arts where porcelain is employed either as a structural member or for the purpose of acting as an insulator under conditions where it must sustain a considerable load.

Porcelain is a difficult material to test in the ordinary standard testing machine because of its brittleness, so that the methods described in the paper will be found useful for all future tests of this material made in any laboratory.

The Society is to be congratulated for the success of this investigation, which is one of the results of the activity of its Research Committee. The field covered by the investigation gives information of the strength when subjected to tension, bending or compression strain, and for that reason is complete to a remarkable degree, especially when the difficulties which had to be overcome in making the tests are considered.

L. E. BARRINGER[1] (written). The mechanical strength of porcelain is satisfactory in some respects and decidedly unsatisfactory in others. The most consistent property is the resistance to crushing and the most erratic and unsatisfactory is the toughness, or resistance to the sudden shock of impact or vibration.

A few years ago I stated that in our experience with vitrified porcelain used for electrical insulation we had found an average compressive strength of 20,000 lb. per sq. in., and a tensile strength of from 900 to 1800 lb. per sq. in. The tension tests were made upon briquettes of the standard shape used in cement testing, with the use of special clips and cushioning materials, and the compression tests on 2-in. cubes. Professor Boyd's paper indicates a compressive strength for porcelain of the same value; I think 20,000 lb. per sq. in. is a safe basis for the calculations of designing engineers.

The comparatively high and uniform compressive strength for porcelain, as compared to its other mechanical strengths, has led engineers to take advantage of this property as much as possible, and certain types of line insulators are designed to bring the strains upon the porcelain as nearly to compressive as possible.

In several instances porcelain, because of its high insulating value and weather resistance, has been found quite the best material for insulation in electric railway equipment. In this particular field, however, porcelain can only safely be used in compression, and would meet with early failure if subjected to tensile, transverse, or impact strains.

In the matter of determining tensile strength the conditions are more complex than in developing compressive strength. The author shows it is quite necessary to devise special clips and cushioning materials to develop the true tensile strength, and in his tabulation of conclusions states that even his very carefully conducted tests failed to develop the real tensile strength of either porcelain or stoneware.

Inasmuch as the paper states only 3000 lb. per sq. in. could be developed, and this with the use of special clips, cushioning material and manipulating, although the true strength was probably 7000 lb. per sq. in., it is suggested that a working figure of 1500 lb. per sq. in. be taken for tensile strength.

One point in connection with the mechanical strength of porcelain is the effect of temperature changes. In the kilns a marked difference of strength will be found, depending upon the rate of cooling. In the finished product temperature changes even within the range of 20 to 90 deg. cent. have an influence upon the mechanical strength. In general, sudden temperature fluctuations cause lowering of mechanical strength; and temperature changes in the finished porcelain, even though brought about at a comparatively slow rate, will have a harmful effect within certain ranges. Porcelain baked at 90 deg. cent. exhibited a decided weakness upon cooling.

The effect of temperature changes is more pronounced as the rate of fluctuation increases, and has the greatest effect

[1] Engr. of Insulations, Gen. Elec. Co., Schenectady, N. Y.

upon the toughness. The tensile and transverse strengths are next most seriously affected, and the compressive strength least of all.

F. M. FARMER presented a written discussion. He stated that this constructive paper represents a considerable amount of very careful and obviously reliable work which will be particularly appreciated by all electrical engineers who have had to do with porcelain insulators. There is a remarkable dearth of reliable information of this character on porcelain.

The paper is, however, of interest for another reason, namely, it emphasizes the small amount of research work which is being done on standard engineering materials. The importance of this general class of research work is frequently overlooked. The ultimate commercial engineering value of such data is often, and perhaps usually, much greater than that obtained from researches which have terminated in more startling results. Many of our common engineering materials are constantly changing, due to improvements in the methods of manufacture, different methods of treatment, etc., and consequently their properties should be redetermined occasionally.

Porcelain, for example, has been improved very greatly in the last fifteen years and yet, despite the enormous increase in its use for purposes where knowledge of the physical properties is important, no reliable data are available on such an

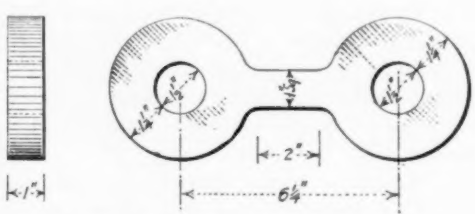


FIG. 1 PORCELAIN TEST PIECE

important property as tensile strength. In this paper it is concluded that the tensile strength of porcelain is above 3000 lb. per sq. in., whereas the usual sources of information give the value as 650 to 2200 lb. per sq. in. These latter figures were undoubtedly obtained many years ago and do not apply to the modern porcelain.

It will be conceded that no general conclusions as to the strength of porcelain can be drawn from the small number of tests described. While four or five specimens of a given sample of porcelain may be sufficient, it is necessary to test not only samples of as many different makes as possible, but samples of different thickness, and samples which have been subjected to various temperatures and periods in firing, etc.

Nothing is stated as to the kind of percelain tested. Presumably it is what is known as electrical porcelain, but further information would have been desirable, such as the kind of clays used, methods of firing, temperature of the furnace and time of firing.

A form of grip and of test specimen which would develop the maximum strength of the porcelain would be desirable. While the conclusions in regard to the tensile strength drawn from the bending and compression tests are probably correct, data obtained by direct tests are more convincing. It would seem off-hand that the rectangular test piece with longer bearing surfaces at the ends would have developed the maximum strength of the porcelain.

T. D. LYNCH [1] (written). We have done most of our testing of porcelain in the final piece as made for service. The sections of such pieces are more or less irregular and for that reason difficult to reduce to a square inch section. We have made a few tests, however, on samples of porcelain with holes in either end for the purpose of attaching clevises, as shown in Fig. 1. Such samples showed approximately 1500 lb. per sq. in. tensile strength, and about 15,000 lb. per sq. in. compressive strength, or ten times the tensile value. These tests are not at all conclusive. Our full-size tests on the finished piece indicate that the strength of porcelain is probably very much influenced by internal stresses, and it would be interesting to know of any study made by the author along this line.

An investigation of the internal stresses in brasses and bronzes was conducted by P. D. Merica and R. W. Woodward and reported before the American Institute of Metals in 1915. Perhaps some similar test could be made on porcelain to determine if possible a heat treatment that will eliminate internal stresses or at least reduce them to a minimum.

JOHN F. ANCONA thought there was a possibility that the peculiar failure of the pieces in the tensile tests might be attributed to some condition of internal stress.

ELLIOTT H. WHITLOCK said that in connection with the effect of temperature of cooling on the homogeneity of the sample he had found that with a certain material the temperature rise curve of the firing had a great deal to do with the final strength. If the temperature rose to a certain point and was then allowed to drop and then again brought up to a higher point, the material was very much weaker than if the same temperature had been reached by a continuous rise. He thought that possibly the rate of firing might have as much to do with the tensile strength of porcelain as the rate of cooling.

PERCY H. THOMAS (written). The author found that fair and reliable results were difficult on account of the great tendency in the test machine for the stress to be applied unevenly to the porcelain section, and also on account of the extreme local stresses at the point of application. While great care was taken in this work to eliminate such effects, other forms of specimens and other methods of holding the test pieces might be much better.

Porcelain is used in practical service in certain cases in such a way as to be called upon to support very material stresses, and does so very reliably. But in practice the shape of the porcelain pieces and the method of support are such as to avoid the difficulties found in the tests described. For example, the high tension suspension type porcelain insulator serves to give mechanical support to a line conductor, at the same time insulating it. The porcelain part, as far as we are here concerned, is a cup in which an iron pin is fastened by filling the cup with Portland cement. The cup is held on the outside by a metal cap into which it enters and to which it also is secured by Portland cement. When the inner pin is pulled out in the testing machine, the metal cap being made fast to the resisting jaw of the machine, the porcelain cup is pulled apart, leaving its bottom portion in the cap, and the rim following the pin. The characteristic fracture is that of tension stress. A porcelain cup 1 in. internal diameter and with a wall ¾ in. thick may resist a stress as high as 13,000 lb. in some instances, which is equivalent to 2500 to 3000 lb. per sq. in., assuming an even distribution. But as this stress must be greater near the surface of the wall than on the interior, the true unit stress must be much higher. This corresponds fairly well with the test values of the paper.

[1] Research Engr., West. Elec. & Mfg. Co., E. Pittsburgh, Pa.

Furthermore, in spite of the very serious stresses to which these insulators are subjected, there are no signs of brittleness or unreliability in service on this account.

The conclusion would be that, when properly used, porcelain is a very strong and reliable material, and by no means deserves the reputation it has been given by its behavior in tests of porcelain rods and narrow tubes.

John A. Brashear. For nearly twenty-five years I have thought of using or attempting to use a porcelain disc of a special design instead of glass for a reflecting telescope. Silvered glass mirrors were introduced some forty years ago; that is, silvered on the front instead of the back surface, and I have thought in the case of large glasses, the disc could be made of porcelain, which could be given an approximate curvature before the enamel was deposited upon it, and if this enamel could be put on thick enough, then ground, fined and polished, and then the surface silvered, it would make a very excellent substitute for the glass mirror. I do not know whether any studies of the coefficient of the expansion and contraction of porcelain have been made, but in the glass disc it is an important factor, so that in the case of large telescopes it gives very great trouble. In the case of the 72-in. reflector which we are now making for the Canadian Government, the disc alone, which is 12 in. thick, weighs two and one quarter tons; and the 100-in. which is being made for the Mt. Wilson Observatory, weighs in the neighborhood of four tons. If this weight could be reduced in the porcelain disc, and the material be made homogeneous, with a coefficient less than glass, it would be a great advantage to the instrument itself.

The Author. In regard to internal stresses, mentioned by Mr. Lynch, it was first thought that the failure of the round rods at the head was due to this cause. Accordingly the rectangular pieces were made with a gentle change of slope, and considerable care was used to so handle the clay as to leave all parts of the piece in the same condition. The nature of the failure of these pieces seemed to indicate, not internal stress, but the combination of the direct tension with the tension resulting from the transverse compression of the grips. As suggested by Mr. Farmer, a grip with larger bearing surface should make it possible to develop the full tensile strength. The head of the test piece should enlarge somewhat more rapidly than shown in Fig. 2.

Transverse compression not only weakens a rod subjected to longitudinal tension but also strengthens it for longitudinal compression. Bands around porcelain rods near the ends seem to have the same effect as in hooped concrete columns.

Internal stress is probably an important factor in insulators where there are rather abrupt changes of section. In metals the amount of internal stress may be determined by measuring the dimensions of a small portion, then cutting it free from the rest of the body and measuring again. The difficulty of cutting makes this impracticable with porcelain. A form of test bar with an enlargement or contraction near the middle will enable one to separate the effects of compression of the grips from those of internal stress and unequal distribution of stress. To differentiate completely between these last two factors may not be possible, but series of tests varying one at a time the two elements of heat treatment and form of piece should give valuable results. Whatever internal stress is found may be due either to the heat treatment or the mechanical treatment of the wet clay, and another set of experiments will be necessary to settle all these questions. For testing these pieces, bending tests with a constant moment for a considerable length will be found easier to apply than direct tension tests.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

In its report to the Council, published in The Journal for December 1915, the Publication Committee presented a carefully thought-out plan for the publications of the Society, certain features of which it has already been possible to carry out. Several letters commenting on this plan have been received, which are published herewith. The recommendations of this Committee are also reprinted in this connection for convenient reference.

TRANSACTIONS

1. That the publication of the annual volume of Transactions be continued.
2. That it be published in the same size and binding as heretofore.
3. That it shall contain, subject to the approval of the Publication Committee, all of the papers and discussions presented at meetings of the Society (not including section meetings), and technical reports of Committees; and shall contain a syllabus of each paper, summarizing the essential facts and conclusions.
4. That it shall contain all the papers and discussions presented at section meetings which in the opinion of the Publication Committee are of sufficient merit.

REVISES

That additional revised copies of the papers and discussion be printed and bound in pamphlet form at the earliest practicable date. A charge will be made for such pamphlets.

ADVANCE PAPERS

That papers for the meetings of the Society be printed in pamphlet form in advance, as heretofore, and be sent to members gratis upon request, a notice of these papers with syllabi, being printed in The Journal one month before meetings.

THE JOURNAL

1. That The Journal be published monthly as heretofore, but with the view to making it a semi-monthly or a weekly as soon as the amount of matter to be handled requires it and funds for that purpose are available.
2. That the size of The Journal shall for the present remain as it now is.
3. That The Journal shall contain:
   a All of the papers and discussion presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.
   b Papers, or abstracts, with discussion, presented at meetings of Local Sections.
   c Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.
   d Department for contributed discussions on papers previously published, or new matter.
   e Members correspondence department, including suggestions on Society affairs.
   f Review of World's Technical Press.
   g Review of technical books, by experts selected by the Committee.

PUBLICATIONS OF THE SOCIETY

To the Editor:

I think Professor Christie's letter expresses exactly my opinion and judgment of the publication matter. While the out of town members constitute the majority of the Society's total enrollment, this does not fully state the fact, because a very small percentage of the local members attend meetings, so that but a small fraction of the total out of town membership is present whenever papers are presented.

Furthermore, the discussion from such sources naturally tends to be verbal rather than written, and expresses less mature thought, or at least not so careful presentation.

In my own case, I never have sent for advance copies of papers, and probably never, or at least very rarely, will, because I am, like a good many others, extremely busy. I cannot tell from the summary of a paper whether it is really worth while or not, but I can tell very quickly by sketching over it, as I always do with the Proceedings of the American Society of Civil Engineers. Of two papers of the same title, and having approximately the same summary, one might, in my opinion, be extremely valuable and merit extended and careful discussion on my part, and another composed to such an extent of generalities and mere presentation as not to be worth my careful reading.

It is my experience that, speaking by and large, probably the most suggestive portions of papers presented to the American Society of Civil Engineers have been found by me in discussions, or at least brought out by such discussions. Consequently, I feel very strongly that no trouble or expense should be spared to increase even by a small percentage the number and quality of discussions of papers. My own personal judgment, therefore, is that positively the best expenditure which the Society could make would be to return to the earlier plan of publishing all papers in The Journal before meetings, just as is done by the Civil Engineers and the Electrical Engineers.

H. T. Cory.

San Francisco, Cal.

To the Editor:

Referring to the report of the Publication Committee, I do not hold my opinions of much value, but am giving you them for such appraisal as you may make of them.

TRANSACTIONS

1. I should not like to see the annual volume discontinued; it is of much value to me.
2. If published in the same same size and binding as before it will suit me better than if changed. I have all of the previous volumes, and I consider them as large as one cares to handle or provide cases for.
3. I think it should contain all approved papers and discussions.
4. There might be some meritorious papers at section meetings that should be included. There is so much rehashing of matter, and publication of stuff that is only filling, that a careful pruning by the Editors is advisable.

JOURNAL

1. Yes.
2. Satisfactory to me.
3. (a) Yes, if not involving too much expense.
   (b) Such as are considered of sufficient value to warrant their publication in the transactions.
   (c) Yes.
   (d) Yes.
   (e) Yes.
   (f) Doubtful value to me. These would perhaps involve more expense than the work would be worth, and in some cases work to the disadvantage of the Society.
   (g) No.

REVISES

This should be left to the Publication Committee who could respond to such demands as were made.

ADVANCE PAPERS

Not necessary if item (a) under Journal is complied with. Otherwise, yes.

Jno. C. White.

Madison, Wis.

To the Editor:

I am much pleased to learn that the publication of the Transactions is to be continued in volumes corresponding to those which we already have, and that they will contain as heretofore all the technical material of value resulting from the meetings of the Society. Those who have been connected with the Society for a number of years set great store by the Transactions in their complete form and wish to keep the form and style intact.

The publication of advance papers will also aid in bringing out discussion both oral and written and will thus add to the value of the meetings. These advance copies are also convenient for filing under subjects in the libraries of the members. It is sometimes desirable to file a paper on some particular phase of engineering together with publications of similar import for convenience of reference. The Journal itself would be more usable and more in accordance with the general scheme if it were printed in the usual 6 x 9 size. The publication of papers in The Journal could be largely dispensed with as unnecessary and the text confined largely to matters of general interest, such as reports of meetings, announcements of meetings, reviews of publications and periodicals and other miscellaneous material which would not appear in the Transactions. Matter which would naturally appear in the ordinary technical journals of the country is out of place in The Journal of the Society. Nothing should be published in The Journal at additional expense which can just as well be read elsewhere; in other words, The Journal should be what the name implies, a monthly record of Society matters which do not appear elsewhere. The small size is much more convenient for library purposes as it conforms to the ordinary pamphlet filing cases.

C. H. Benjamin.

Lafayette, Ill.

To the Editor:

The writer has the following comments to make on the plan for publications of the Society.

Under Transactions and Revises the writer agrees entirely with the outline as published.

Under The Journal the writer would raise objection to the present size of The Journal. It is large and unwieldy and not convenient for ordinary perusal. It is believed that the former size of The Journal, or the size used by fiction periodicals, would be very much preferable. This statement is made after several years experience with both sizes, and the regular receipt of publications of other societies not printed on the large page now used by The Journal.

Under paragraph 3 the writer would suggest that in The Journal all discussion be omitted. By doing this, the original papers could be printed in fairly complete form in The Journal as far in advance as possible, and in our opinion would be ample record for the members until such time as the

Transactions were published. This would also do away with the publication of advance papers except in cases where publication in The Journal would not be possible previous to the presentation of papers.

W. B. SANFORD.

New York, N. Y.

FAHRENHEIT SCALE

To the Editor:

As you probably know, a paper is being circulated for expression of opinion relative to the discontinuance of the Fahrenheit thermometer scale. This paper is being sent out by a member of Congress, Representative Johnson of Washington.

I wish to know what attitude is being taken by the Engineering Societies regarding this matter. There has been quite a determined stand taken against the forcible adoption of the metric system, but I am not sure whether this extends to the use of the Fahrenheit scale. The change would cause considerable commotion in our definition of heat units.

P. F. WALKER.

Lawrence, Kansas.

[Comments from the membership on the question raised by Prof. Walker will be appreciated by the Secretary.—EDITOR.]

DEVICE FOR RECORDING DATA IN A BOILER PLANT

To the Editor:

The instrument illustrated herewith has been designed in an endeavor to produce a device that will assist the responsible head of a boiler plant to a knowledge of the performance of his boilers, hour by hour, without the necessity of analyzing in detail the figures of the daily coal and water logs. The boiler room superintendent usually knows pretty closely how many pounds of steam ought to be evaporated per pound of coal burned, and he is principally interested in learning, with the least amount of work, whether his assumed standard of economy is being consistently maintained.

The instrument, which for lack of a better name has been styled the *Econograph*, is conveniently located in the manager's office. It produces a daily chart that shows by separate lines, but simultaneously, the water rate, the coal rate and whether the ratio of water to coal has fallen below the assumed standard. The chart not only shows whether the desired degree of economy has been maintained, but also, in the event of the economy falling below the desired standard, the chart shows the time of day when the drop occurred, and for what length of time the boilers were run at a degree of economy lower than the assumed standard. The diagram also assists, by mere inspection, in locating the cause of falling off, that is, it indicates whether the poor economy was brought about by decrease in evaporation, or by unusual increase in fuel.

The daily chart consists of four lines or curves, coincident as to time, but independently recorded on the chart as follows:

1. A line showing the amount of water fed to the boilers;
2. A line showing the fuel fired;
3. A line showing the time at which unevaporated water was withdrawn from the boiler, through the blow-off or otherwise.
4. A line showing the time at which the economy of steam production fell below the assumed standard of performance which was expected to be maintained, and the time when the desired standard was regained.

The water line on the chart gives, to scale, the total water fed to the boilers at any given hour, in thousands of pounds. The inclination of this line from the horizontal shows approximately the rate at which water was being supplied at any given time, and shows fluctuations in rate of water supply. The fuel line shows the total fuel fired at any given time and the rate of firing. Thus, the slope of the water and fuel lines indicates at a glance the probable cause of any change in economy.

The hour at which an apparent change occurs is automatically shown so that the time of commencement and the end of a period of inefficient operation on the day-shift, night-shift, or at any time, is recorded beyond dispute. If standard economy, or better is being maintained, the chart shows it, indicating that there is no necessity for analysis of the water and coal logs; but if economy drops, the time at which the drop occurs, is definitely fixed and an analysis of the coal and water

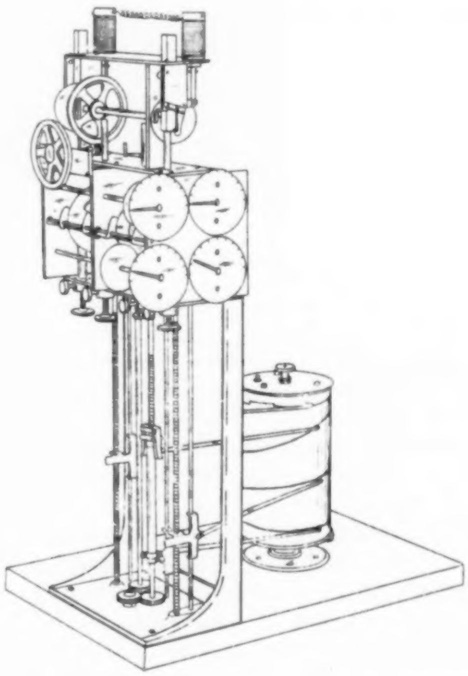


FIG. 1 DETAIL VIEW OF THE ECONOGRAPH INSTRUMENT

logs for that period of time should be made to locate the fault.

The instrument comprises a clockwork drum carrying a sheet of paper on which four pointers draw independently the lines above referred to. One of the pointers is connected through a train of gears and an electrically operated tripping mechanism with a contact switch connected to a water weigher, or to the recording device of a flow meter that measures the amount of water fed to the boilers, or it may be connected with the recorder of a steam-flow meter. The second pointer is connected through a similar set of gears and an electric tripping device with a moving part of the stoker, or with an automatic coal scale, or with a contact device actuated by wheel-barrows or carts delivering coal to the boilers, as the case may be, or if gas or oil is used for fuel, the pointer is actuated by contacts on the indicator of the fuel meter.

The third pointer draws a straight horizontal line so long as the ratio between water and fuel is equal to or greater than the standard which it is desired to maintain, but when the ratio of water to coal drops below the standard, this pointer makes a break in the diagram at the hour when the drop occurred, and the line remains broken until such time as effi-

ciency again reaches standard. This broken line gives unmistakable notice to the plant manager, who can refer to the water and fuel lines directly above to ascertain the probable cause, and he can then make the usual analysis of his boiler room water log and coal log covering the time in question and can institute proper inquiries in the fire room.

The third pointer does not draw attention to economy that is better than standard, because it has been found impractical in practice to attempt to record diagrammatically minute fluctuations in the ratio of coal and water, and it is sufficient for practical purposes to indicate sharply, as by the broken line, only those times when performance falls below standard.

The fourth pointer is connected by an independent circuit to the blow-off valve of the boiler, and shows by a break or jog in its line, the hour at which the blow-off valve is opened, and the length of time it remains open, to direct attention on the diagram to the time at which unevaporated water was removed from the boilers, in order that it may not be inadvertently figured as having been evaporated.

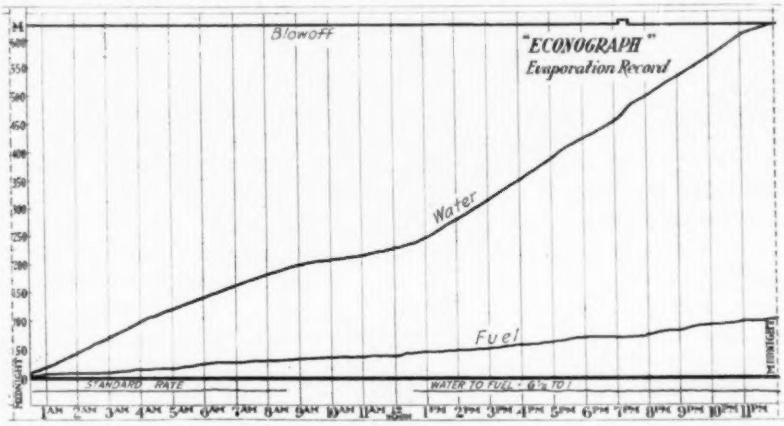


FIG. 2 A 24-HOUR RECORD OF BOILER OPERATION MADE BY THE ECONOGRAPH

The diagram may be of either twelve or twenty-four hours' duration, and is usually made on transparent paper, so that the chart of one day's run can be compared with that of another day by laying one chart on top of the other. In reading a finished chart, it is seen at first glance whether the standard performance has been maintained, the hour at which economy fell below standard, and at what time it was regained.

Directly above is the coal line which extends upward from left to right across the sheet and its inclination shows at a glance whether there has been any sudden increase or decrease in the coal rate. The water line is directly above the coal line, and its inclination shows any apparent variation in rate of water supply.

Thus, the bottom line, which is called for convenience the *efficiency* line, draws immediate attention to poor economy, while the coal line and the water line show at a glance whether the drop in efficiency is probably due to change in rate of coal or water supply. If the blow-off valve has been opened and water has been withdrawn from the boiler without being evaporated, the top line of the diagram shows at what time it occurred.

The total coal and total water at any hour can be measured approximately on the diagram, and by laying a ruler along the slope of the water line or the coal line, the operator can estimate the coal or water in pounds per hour at that time. A little practice enables one to easily estimate these quantities very closely.

The primary object of the device is to record on paper and to draw attention to those times at which poor economy obtains, and to indicate to the engineer (by the independent water and coal lines) where the trouble is likely to be found. An analysis of the boiler-room logs of coal and water for the period of poor economy will reveal the cause in the usual way.

The instrument is not intended to take the place of the technical knowledge requisite to maintain high boiler economy, but it does away with some of the tedious work of analyzing boiler data, and calls attention to those times of poor economy which it is profitable for the engineer in charge to study, referring back to his log data.

To adapt the device to conditions at different plants, it is provided with adjustments, such as dials that indicate periodically the times at which charges of coal and water are supplied. Another pair of dials shows the ratio at which the machine is set; thus, if it is desired to maintain a standard evaporation of, say, 7 lb. of water per pound of coal, the latter dials will show a ratio of seven to one. This ratio can be set within reasonable limits to any desired standard. The adjustment is made by turning the vertical thumb-screws shown below the dials.

No two plants deliver coal and water in exactly the same size charges, that is, one boiler may be fed by a coal weigh-scale which delivers 300 lb., and another boiler will be fed by a scale that delivers 500 lb., and similarly with the water supply. The device is, therefore, provided with adjusting screws by which the units of coal and water are converted to equivalent scales on the chart, so that the water line and the coal line of the diagram can be measured to the same scale.

The instrument records with accuracy the correctness of the recorded results depending upon the accuracy with which the units of fuel and water are measured before being supplied to the boilers. Details of the mechanism would be of little interest in this description, although they are simple in construction. It is here desired to merely describe the results attained by the device as a means for assisting the power plant manager to arrive at a quicker and easier analysis of his boiler performance.

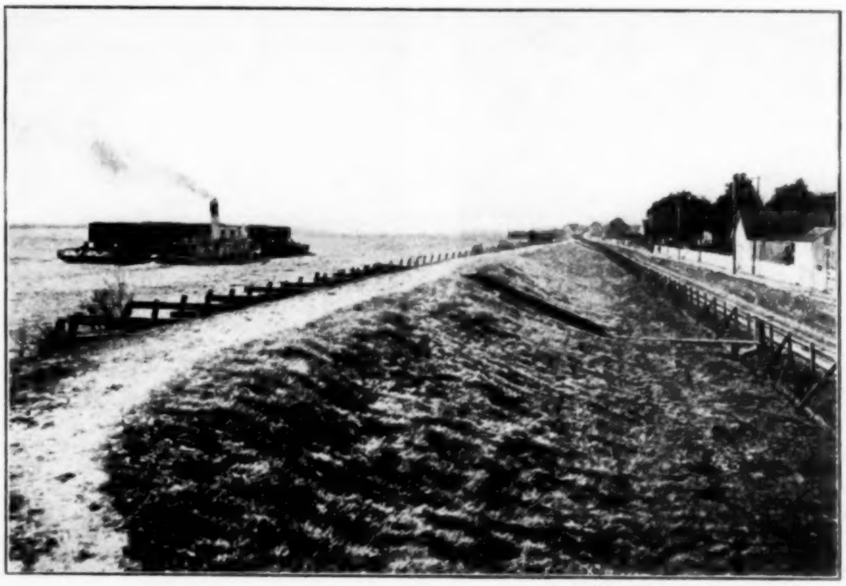
GEORGE B. WILLCOX.

Saginaw, Mich.

SOCIETY AFFAIRS

THE SPRING MEETING AT NEW ORLEANS

THE Committee on Meetings and the New Orleans Committee of Arrangements have practically completed their plans for the Spring Meeting to be held at New Orleans, April 11 to 14. Information regarding the program, hotels, transportation and features of interest to be inspected at New Orleans is published herewith, and will be followed in a few days by a circular to the membership giving further and later details.



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Mississippi River and Levee near New Orleans

Everything points to a meeting which to most of those who attend will prove unique. The problems of the engineer in the South are peculiarly his own and not only will certain of these problems be considered during the professional sessions, but every facility will be afforded to visit industrial plants and to witness engineering construction work which are typical of the industries and undertakings of that part of the country.

Headquarters will be at the Hotel Grunewald and the meeting will open as usual on Tuesday afternoon of the week of the convention and close on Friday, but it is hoped that many will remain over during the day Saturday for the purpose of making inspection trips in the vicinity.

There are several plants near New Orleans which are peculiar to the locality, but due to infrequent train service, or other reasons, it requires about a day to visit them. For this reason, the Committee decided not to plan definitely for excursions to these plants during the time of the meetings, but have arranged instead for inspection parties on Saturday for the benefit of such members as may stay over another day. The plants which the Committee have particularly in mind are the salt mines at Weeks Island and Avery Island; the sulphur mines at Sulphur, La.; the oil refineries near New Orleans or at Baton Rouge; the sawmill of the Great Southern Lumber Company at Bogalusa and wood distillation plant at Slidell, La.; rice irrigation pumping plants in Western Louisiana and the oil fields of Western Louisiana and oil and gas fields of Northern Louisiana.

The tentative program is published on the next page. Attention is called in particular to the opening session on Wednesday morning, when there will be a discussion upon Industrial Preparedness: What it Means and How it Can be Accomplished.

Following this session the visiting members will be in the hands of their New Orleans friends until Friday morning of the convention, when the last professional session will take place. The New Orleans Committee have in preparation one session for their part of the program which will include papers upon the evolution of low-lift pumping plants in the Gulf Coast country; tests upon the capacity and economy of multiple evaporators; and the mechanical equipment used at the docks in the Port of New Orleans.

Papers to come up for discussion at the session on Friday

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One of the Excursions During the Spring Meeting will be to the Reclaimed Land near New Orleans

morning will treat of miscellaneous subjects, notably the measurement of the flow of fluids and related topics; the dynamic balancing of rotating bodies, the measurement of viscosity and the flow of heat.

TENTATIVE PROGRAM

Tuesday, April 11

AFTERNOON.... Registration.
EVENING...... Informal Reception.

Wednesday, April 12

MORNING...... Business Meeting, followed by Professional Session on "Industrial Preparedness."
AFTERNOON.... Trip on the river which will give an opportunity to view the harbor as a whole and inspect the new cotton warehouse and other features of interest.
EVENING...... Address for the general public, by Mr. W. B. Thompson, Commissioner of Public Utilities of the City of New Orleans.

Thursday, April 13

MORNING...... Professional Sessions at which papers will be given on engineering subjects of local interest.
AFTERNOON.... Entertainment at Country Club, or some other excursion.
EVENING...... Reception and dance.

Friday, April 14

MORNING...... Professional Sessions.
AFTERNOON.... Excursion to reclaimed land near New Orleans.

TRANSPORTATION NOTICE

The Committee on Meetings has been pleased to accept the invitation of the Section of the Society at Birmingham, Ala., to make a stop in that city on the trip to New Orleans. A train schedule as given below has been designated by the Committee for those going from the vicinity of New York, which allows a stop of 24 hours in Birmingham. The route is through Washington and Chattanooga via the Short Line (comprising the Pennsylvania, Southern, Norfolk and Western, and Queen and Crescent Lines). The Pullman cars of the train will be parked at Birmingham so that members may conveniently spend the entire day, Monday, in accepting the hospitality of the Birmingham Section.

While it is expected that a number will prefer to go to New Orleans by boat rather than by train, and that, on the other hand, some, unable to take the time for the stop at Birmingham, will leave a day later than the schedule indicates, it is hoped that as many as possible will take the official train in order to add to the sociability of the journey.

TRAIN FROM NEW YORK

Leave New York via Pa. R.R. 3 : 34 p. m., Saturday, April 8.
Arrive Washington 9 : 15 p. m.
Leave Washington via Southern Railway 9 : 45 p. m.
Arrive Birmingham 10 : 25 p. m., Sunday, April 9.
Leave Birmingham 10 : 35 p. m., Monday, April 10.
Arrive New Orleans 9 : 40 a. m., Tuesday, April 11.

Full information concerning trains and reservations may be obtained from W. V. Kibbe, District Passenger Solicitor of the Pennsylvania Railroad Co., 501 Fifth Avenue, New York.

TRAINS FROM CHICAGO AND CINCINNATI

The Executive Committee of the Cincinnati Section has designated the train leaving Cincinnati on the Queen and Crescent Road at 8 a. m. Sunday, April 9, as the official train from Cincinnati. This train is scheduled to arrive in Birmingham Sunday night as a part of the same train on which the New York members will travel, as mentioned above.

The Committee of the Chicago Section of the Society proposes the schedule given below, with the idea of accepting the Birmingham invitation and at the same time having the company of the Cincinnati Section from that city to New Orleans, and also of joining the New York Section at Birmingham.

TRAIN FROM CHICAGO

Leave Chicago, Big Four, 11 : 45 p. m., Saturday, April 8.
Arrive Cincinnati, Big Four, 7 : 55 a. m., Sunday, April 9.
Leave Cincinnati, Queen & Crescent 8 : 00 a. m., Sunday.
Arrive Birmingham, Queen & Crescent 10 : 25 p. m., Sunday.
Leave Birmingham, Queen & Crescent 10 : 35 p. m., Monday, April 10.
Arrive New Orleans, Queen & Crescent 9 : 40 a. m., Tuesday, April 11.

The route between Cincinnati and Birmingham is via Chattanooga, at which point the trains bearing the New York Section and Chicago Section will be consolidated, thus affording an opportunity for visiting en route between Chattanooga and Birmingham. The time of arrival at Chattanooga of the New York Section will be 5.55 p. m. and of the Chicago Section 6.10 p. m.

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TERMINAL STATION, NEW ORLEANS

TRIP BY BOAT

For those desiring to go by boat, the Southern Pacific Company offer accommodations on their steamer Proteus, which leaves New York at 12.00 o'clock noon on Wednesday, April 5, arriving at New Orleans on Monday, April 10, at 10.30 a. m. This offers a delightful five day voyage in a first class steamer, excellent cuisine, courteous attention, a restful trip. For those desiring to return by boat, it may be stated that a boat leaves New Orleans for New York on Saturday, April 15, at 10.00 a.m., and is due to arrive in New York Thursday, April 20, at 7.00 a.m. No official train schedule is being arranged for the return trip.

Reservations for the boat trip, going or coming, may be obtained from J. M. Adler, Passenger Agent, 1158 Broadway, New York.

FARES

The individual round trip by rail between New York and New Orleans is $56.30. Pullman fare from New York to New Orleans is $8.00 for lower berth, $6.40 for upper berth.

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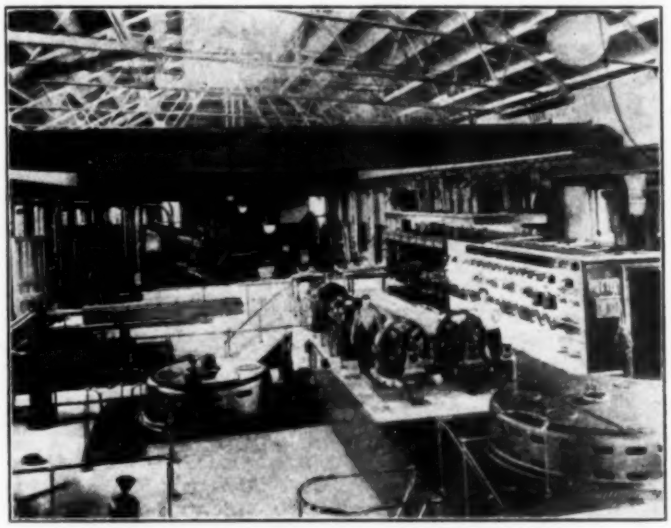
COTTON ON THE LEVEE



DRAINAGE STATION NO. 1

There is practically no reduction for large parties, the rate for ten or more going and returning by rail being $55.38.

The round trip fare between Chicago and New Orleans is $37.40.

The round trip fare, either going one way or both ways by boat, between New York and New Orleans, is $75.00. This includes meals and berth on the steamer and provides also for those starting from an inland city, such as Cincinnati, to go by rail to New Orleans, returning to New York by boat and thence by rail to the point of starting. For parties of ten or more going on one ticket by rail and returning by steamer, the round trip is $70.19.

A charge of $2.00 per capita will be made for parking the cars for occupancy at Birmingham.

HOTELS

The Committee on Hotels of the New Orleans Committee of Arrangements has selected the Grunewald Hotel as headquarters for the Spring Meeting. The rates are as given below and members are requested to write direct to the hotel for reservations. The Grunewald has sufficient capacity to accommodate all visiting members, but in case any should prefer to stay at another hotel, rates are also appended for the three others recommended by the committee, all within three squares of the headquarters. The rates are as follows, on the European plan:

HOTEL GRUNEWALD

New Building	
Rooms without bath, one person	$1.50 per day and up
Rooms with bath, one person	3.00 per day and up
Rooms without bath, two persons	2.50 per day and up
Rooms with bath, two persons	4.00 per day and up
Main or Old Building	
Rooms without bath, one person	$1.00 per day and up
Rooms with bath, one person	2.50 per day and up
Rooms without bath, two persons	2.00 per day and up
Rooms with bath, two persons	3.50 per day and up

ST. CHARLES HOTEL

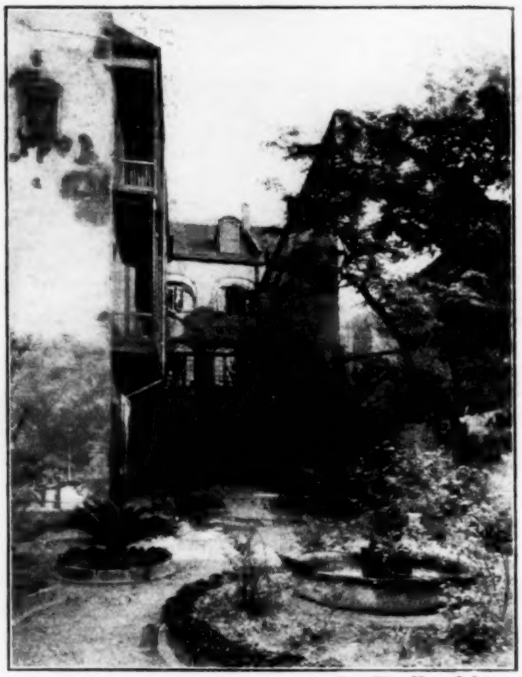
Room with detached bath, one person	$1.50 per day and up
Room with bath, one person	2.50 per day and up
Room with detached bath, two persons	2.50 per day and up
Room with bath, two persons	4.00 per day and up
Parlor suites	10.00 per day and up

HOTEL DE SOTO

Room without bath, one person	$1.50 per day and up
Room without bath, two persons	2.00 per day and up
Room with bath, one person	2.00 per day and up
Room with bath, two persons	3.00 per day and up
Rooms with connecting bath, two persons in each room	3.00 per day per room

12-FT. SCREW PUMPS, DRAINAGE STATION NO. 1

DISCHARGE FROM ONE 12-FT. DRAINAGE PUMP



Coquille, New Orleans.

Courtyard in French Quarter

COSMOPOLITAN HOTEL

Room with bath, one person	$2.00 per day
Room with bath, two persons	3.00 per day
Room without bath, one person	1.00 per day

ENGINEERING FEATURES AT NEW ORLEANS

Interest in New Orleans from an engineering standpoint centers in the accomplishments of the past few years toward securing facilities adequate for handling the commerce of the Mississippi Valley with the outside world. In this respect the city and state have worked together and along with this development have come marked advances in the social and educational life of the community, through the modernization of the city government, the completion of elaborate systems of sanitation, the drainage of large contributory areas of land and the splendid growth of various educational institutions.

New Orleans has spent $28,000,000 in one of the most com-

Coquille, New Orleans.

A Spot of Rare Beauty

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St. Charles Avenue, New Orleans

plete systems of sanitation in the world, comprising water supply, sewerage and drainage systems.

The water supply includes an extensive system of sedimentation and filtration, with two main pumping stations of 80,000 gallons per day capacity and several hundred miles of mains.

Coquille, New Orleans.

Tropical Foliage at New Orleans

The sewerage system, with two large pumping plants, has been in operation since 1905.

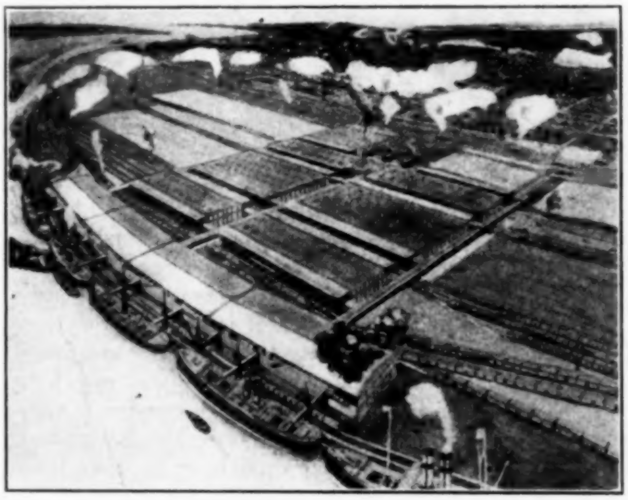
Immediately about New Orleans over $20,000,000 are being expended in draining the wet lands with most favorable conditions resulting as to health and the possibilities of intensive cultivation for farm and garden products. The inspection of this drainage area is one of the visits planned for the Spring Meeting. This project, and that for water supply, have called for pumping plants of immense capacity which are of prime interest to the engineer.

The river front at New Orleans is publicly owned and has been rendered doubly useful by a municipally-owned belt line

connecting the various trunk lines, wharves and manufacturing plants of the city. A large sum has been expended in the construction of modern docks, wharves and steel sheds for the handling of freight. The recently built state warehouses for the storage and handling of cotton constitute one of the great institutions of the country for facilitating transportation.

These warehouses required an expenditure of $3,000,000 and were constructed at a minimum cost, the determination of which involved a careful study of several factors, such as the ratio of storage capacity to amount of cotton handled, the questions of single or multi-story buildings, the height to which the bales would be piled or tiered, and the mechanical handling of the cotton. One of the devices contributing to the success of the plan as developed is a mechanical "bale-puller" for the purpose of extracting any bale from any pile without moving any other bale.

Because of public ownership it has not been possible for an



An Excursion Is Planned to the Immense Cotton Warehouses Recently Constructed at New Orleans

industry to erect buildings on the batture of the river except for the purpose of "commerce and navigation." In consequence, another important development is now underway in the nature of a ship canal connecting the gulf and the river which will give opportunity for waterside location for the manufacturer, besides increased facilities in receiving his raw materials and in shipping his products.

FEATURES OF GENERAL INTEREST

Besides the engineering features of New Orleans, the visitors at the Spring Meeting will find many delightful places to visit in the city, as evidenced by the several glimpses in the illustrations appearing in this number. The quaintness of the French quarter with its courtyards, antique stores and famous restaurants, the tropical vegetation, the parks and many beautiful streets, cause the city to rank high among the vacation places of the country. There are public buildings to be visited, the Chalmette Monument, the Cathedral and old residences, many of them of historic interest.

Tulane University, which has been a potent educational factor in Louisiana, is of interest. Newcomb College also appeals to visitors because of its art school, where are produced by the students various art objects, famous among which is the Newcomb pottery.

NOMINATING COMMITTEE

In making a study of the situation, President Jacobus found that no particular method is outlined for selecting five members for the Nominating Committee, but that it has been the practice to select members from different geographical sections of the country, as it would seem that this is the best way of securing the views of the membership at large. He wished to avail himself of the splendid organization and interest of the Sections and with this in mind formed five groups of the different geographic sections of the Society, without respect to the number of members in those sections, and suggested that each of the groups agree on a single candidate, where practicable, to be submitted as a suggestion for appointment on the Committee. The sections were grouped in the following order:

Group 1—San Francisco and Los Angeles
Group 2—Atlanta, Birmingham, St. Louis and Cincinnati
Group 3—Chicago, Milwaukee and Minnesota
Group 4—Boston, New Haven and Worcester
Group 5—New York, Philadelphia and Buffalo

Great interest has been manifested and the President, while not bound to accept the nominations made by the Sections, has in each case taken pleasure in doing so. The nominations are as follows:

Group 1—J. T. Whittlesey, of San Francisco
Group 2—Prof. E. H. Ohle, of St. Louis
Group 3—H. M. Montgomery, of Chicago
Group 4—Walter B. Snow, of Boston
Group 5—D. Robert Yarnall, of Philadelphia

The object of pursuing the above method, as was brought out in an address by the President at the joint meeting of the Chairmen of the Sections held at the time of the Annual Meeting, is to secure the greatest possible democracy throughout the Society and at the same time encourage the selection of those men who by virtue of their high professional standing will in turn choose similar men for officers of the Society. It has been suggested that the Nominating Committee assemble at the Spring Meeting of the Society at New Orleans.

COUNCIL NOTES

At the meeting of the Council held on February 11, 1916, there were present: D. S. Jacobus, *President*, John H. Barr, Robert M. Dixon, *Chairman of Finance Committee*, Arthur M. Greene, Jr., James Hartness, Henry Hess, Frederick R. Hutton, William B. Jackson, Charles T. Main, Spencer Miller, H. de B. Parsons, J. E. Sague, John A. Stevens, Max Toltz, E. H. Whitlock, William H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

A letter from Prof. P. F. Walker relative to an agitation to discontinue the Fahrenheit thermometer scale was referred to the Committee on Research. This is printed in the Correspondence Section.

Roy E. Brakeman, *Chairman*, Charles B. Davis, *Vice-Chairman*, Paul Wright, *Secretary-Treasurer*, J. Henry Klinck and Frank G. Cutler were appointed as a Local Sections Committee in Birmingham; Emmett B. Carter, *Chairman*, W. R. Jones, *Secretary*, Charles L. Bruff, Robt. H. Fernald, Jas. E. Gibson, Jos. A. Steinmetz were appointed as a Local Sections Committee in Philadelphia; A. D. Blake was appointed Secretary of the New York Sections Committee.

The President announced the appointment of D. C. Jackson, *Chairman*, A. H. Kruesi, R. J. S. Pigott, John A. Stevens and B. F. Wood as a committee to coöperate with the sub-committee of the Committee on Standards of the American Institute of Electrical Engineers.

On invitation from the American Institute of Electrical Engineers, soliciting the coöperation of this Society in a proposed joint Pan American Engineering Committee, William H. Bixby, Charles T. Plunkett, C. C. Thomas, Ambrose Swasey and S. W. Stratton were appointed as a committee of our Society.

Major William H. Wiley, Chairman of the Society's Committee of the Joint Committee on Engineer Reserve Corps, reported that this Committee had appeared before the House Committee on Military Affairs and urged with success the inclusion in pending legislation of a provision for a reserve corps of civilian engineers.

A communication from the American Institute of Electrical Engineers regarding the adoption of the metric system in this country was referred to a committee previously constituted to report on these matters.

Calvin W. Rice, *Secretary*.

ENGINEERING FOUNDATION

With its meeting of January 1916, the Engineering Foundation Board completed the first year of its activities. The Board at first was mainly concerned with the preparation of rules of administrative procedure based upon the by-laws of the United Engineering Society under whose auspices the foundation conducts its work. During the summer and early autumn, however, it was able to turn to the consideration of applications for the support of research work, or other undertakings coming within the objects of the foundation.

A committee was created for this purpose consisting of A. R. Ledoux, Alex. C. Humphreys, Past-President, Am.Soc. M.E., M. I. Pupin and J. Waldo Smith, Mem.Am.Soc.M.E., —names which are representative of a wide range of expert knowledge. The applications in hand were considered in sub-committee by assignment to the ones most familiar with the respective subjects.

Sixteen applications have been received. Two were in the class where accepted scientific principles were antagonized by propositions to secure energy greater in amount than would be expended in its production; two were for the attainment of results purely commercial in character and which clearly should be promoted by manufacturers rather than by a scientific board; two were for investigations whose financial requirements were greater than the limitations of income in the hands of the foundation would permit it to consider; and two were for researches already in competent hands and for work well in progress at these establishments. Three of the applications have been deferred for further information and two were not presented in sufficiently complete form to permit of intelligent action. This leaves three upon which the board has taken provisional favorable action of which full report will be made when the final decision on them has been arrived at.

Certain important questions of principle and policy have come to the surface in the discussion of these applications. The one of perhaps widest interest is the question of ownership and development of any patent monopoly which might come to the surface under researches in progress. It was the sense of the board that it was not a business body and could not properly own or license under a patent monopoly which it might own. On the other hand, it might be the duty of the board to prevent monopoly by others by securing patent protection and then making the use of such patent the property of the scientific and industrial public, as is the obligation of officers of the federal government in their respective lines. The question is an interesting one.

1916 YEAR BOOK

With the membership increasing at the rate of seven hundred or eight hundred a year, the problem of issuing the Year Book without sacrificing the features of usefulness which have for several years past characterized the volume becomes increasingly difficult.

First of all, of course, accuracy of name and address is to be desired; second, compactness, so that the book may be carried conveniently in traveling; and third, such an arrangement of the alphabetical and geographical lists as will serve all reasonable needs.

Members have already received the Year Book for 1916 and it will be noted that whereas there are over 700 more names and 1400 more entries than in the previous Year Book, there has actually been a reduction of 65 pages. This reduction was accomplished in part by a re-editing of the entire membership lists and by the use of a condensed but legible type face. Paper manufactured for this book and somewhat lighter in weight than formerly was also employed; by this still greater compactness was secured.

It will be of interest to call attention to the scheme of the alphabetical and geographical lists of this Year Book. In the alphabetical list are given the grade of membership, title and business connections, business and residence addresses. In the geographical list, however, such complete information is not needed, but at the same time it is believed that more information should be printed here than would be comprised in the mere alphabetical listing of the names under each town or city, as is the practice of societies. If a member is visiting a certain city for business purposes, the information which he is most likely to want to draw from the Year Book is the names of members located in that city and the firms with which they are connected. This information, therefore, is given in the geographical list. Every member of The American Society of Mechanical Engineers receives a copy of this complete Year Book, cloth bound.

SECRETARY AT LOCAL MEETINGS

On February 7, the Secretary visited the Student Branch at the University of Maine, Orono; on February 8, the Boston Section of the Society, and on February 9, the Student Branch of Massachusetts Institute of Technology, Boston, Mass.

At the University of Maine, following an address by Dean Boardman, he gave a talk to the engineering students, in which he outlined the work of student branches of the Society and explained the extraordinary service which the engineering profession is giving the nation in connection with industrial preparedness.

In Boston, the Secretary was the guest at the enthusiastic meeting of the Boston Section of the Society, with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers on the occasion of the seventh annual joint banquet of these organizations held in the new Boston City Club, an account of which appears elsewhere. It is seldom that meetings of engineers are held in any city of the country where so large a number get together and so splendid a spirit of courtesy is shown as at these events in Boston. At this dinner, there were over 500 engineers present, men of large affairs, with diversified interests, but having at heart the one

common interest of the engineering profession at large through their relations with the municipality, the state and the nation.

On Wednesday noon, February 9, a few words were extended to the young men of the Technology Christian Association and the Student Engineering Society in the Technology Union, emphasizing the value to the students of the work of the Christian Association in teaching English, drawing, mathematics to the working men. The absolute necessity for all executives to understand men makes it essential that engineers undertake early in their career all those duties which bring them in touch with men. Nothing can be more desirable than rendering a service to working men which will at the same time make them good citizens.

Mr. Rice was subsequently shown over the new Technology buildings and had the satisfaction of seeing the prospective new headquarters for the student branch in the mechanical engineering department.

CIVIL ENGINEERS INVITED TO SHARE ENGINEERING SOCIETIES BUILDING

Negotiations have been in progress between the United Engineering Society, representing the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and The American Society of Mechanical Engineers on the one hand, and the American Society of Civil Engineers on the other, in connection with an invitation extended on June 28, 1915, to the Civil Engineers to share the Engineering Societies Building. These negotiations have necessarily been confined in their preliminary stages to the governing boards of the societies. We are now happy to state that the invitation has finally resulted in a report on the part of the special committee of the Civil Engineers, consisting of Clemens Herschel, *Chairman*, Robert Ridgway, Charles Warren Hunt, Charles F. Loweth and Past-Presidents John A. Ockerson, George F. Swain and Hunter McDonald, that the matter of removing the headquarters from the house on West 57th Street to the Engineering Societies Building favoring the subject be submitted to letter ballot of the entire membership of the Civil Engineers.

In general, if the Civil Engineers should sell their property, they would realize approximately \$325,000, and their share of the cost of the land and other expenses in connection with the Engineering Societies Building would be about \$240,000. They would become a joint owner with the three other societies in a property worth \$1,967,332, one-quarter of which would be \$491,833. In other words, roughly speaking, by a payment of \$250,000, they would have an equity of \$500,000 and \$100,000 in bank. So much for the financial side. On the material side there would be greater hall capacity for their annual meetings which are now seriously taxing their headquarters.

Further, there is now a duplication of effort in the maintenance of their libraries, and it is an open secret that should the Civil Engineers coöperate in the administration of a joint Library an endowment of \$500,000 will be forthcoming. It is not suggested that the Civil Engineers yield title to their books for these benefits, but place them in the same room with the books of the other engineering societies, in which case they will be cared for by the staff of the United Engineering Society and the library as a whole greatly enhanced in value. This would place the joint Library in a unique position on this continent, if not in the world.

Still another benefit would be more frequent conferences of the officers of the national societies, through the natural facility of such conferences, in all matters pertaining to the welfare of the engineering profession as a whole.

There are now approximately two vacant floors in the Engineering Societies Building, occasioned by the recent removal of two societies, one of which wished a ground floor on a prominent street for exhibition purposes, and the general restriction of the building to purely engineering activities, which limits the choice of occupants of the building. It is now possible for the Civil Engineers to come into the building and have similar suites to the other founder societies. Should these accommodations be insufficient, however, the founder societies have generously offered to build an addition on the top of the building. This addition, it is estimated, will cost the entire sum of \$240,000 which the Civil Engineers would pay as their share of ownership. It is reasonably hoped, however, that one or more floors in the present building, arranged to suit the Civil Engineers and duplicating their present facilities, will be adequate.

The engineering profession is demonstrating daily its capacity for service to the nation and society generally, and this outward evidence of coöperation points toward an ideal which all hope may be attained.

INDUSTRIAL PREPAREDNESS

As a result of the invitation from the President of the United States which was published in the February Journal, the Council selected at its last regular meeting, and at a special meeting called for the purpose, the names for directors of the industrial census in each of the states of the Union and the Territory of Alaska and the District of Columbia. There has also been a conference of the committee representing the Society with the committees representing the other four engineering societies who jointly have been invited by the President to undertake this great work.

This census will in reality be the most important undertaking that the government has ever essayed in the matter of understanding the resources of the country, not only for defense but for peace, and the engineers are to be considered particularly fortunate in having received the invitation and in being recognized as an instrument for the service of the nation. It now behooves the engineering profession to appreciate that with this great honor goes great responsibility and that personal sacrifice and service of the highest order is the price that must be paid for further honors.

The main elements involved in industrial preparedness are men, transportation and materials, and it falls to the lot of the engineer to furnish two of these,—transportation and materials.

The following circular issued by the Naval Consulting Board accompanied the letters sent by the Council to the members of the Society in each of the several states of the Union:

For the first time in the history of this country, engineers have been called as a body to its aid. Their service is needed by the Government in the performance of a most important patriotic work. They have been asked to aid in the laying of the foundations of our structure of national defence. Upon every one of them there rests a personal responsibility. The Country needs their service, the President has asked for it, and the governing bodies of the Engineering Societies have confidently pledged it. It is earnestly hoped that each and every one will find it possible to accept this nomination by his Society and to co-operate in this non-partisan, non-political and wholly patriotic work.

Brief outlines of Plan for Inventory of Industrial Re-

sources Available for the Support of the Army and Navy of the United States:

1. Selection by each of the five great technical societies of one American Citizen from each State in the Union, as per President Wilson's request of January 13th.
2. The formal appointment by the Secretary of the Navy of the men so selected as State Directors of the Organization for Industrial Preparedness and Associate Members of the Naval Consulting Board.
3. Each State Board of Directors consisting of five men thus appointed to organize for business—electing Chairman and Secretary.
4. The organization under each State Board of a corps of Field Aides selected from the combined membership of the five technical societies within that State.
5. The issuance by the Naval Consulting Board to each State Board of complete information as to the work in hand, the objects to be obtained, suggested methods of procedure, lists of members within the State of the five technical societies and all available data as to the industries of the State.
6. Examination by the State Board of their territory with reference to the number and geographical distribution of industries with relation to the Field Aides available for the Inventory.
7. Issuance by the State Boards to the Field Aides of Instructions and Blank Forms as supplied by the Naval Consulting Board.
8. Examination and checking by the State Boards of all completed field reports. Following up men to see that reports are sent in properly. Checking reports and supplying any data lacking before sending them to Consulting Board.
9. The continuance of the Organization thus formed in order to insure to the Government the backing of the full industrial strength of the country and to secure for the largest practicable number of industrial concerns such an amount of Government business as will keep them in touch with the requirements of the Army and Navy.

In order to obtain the necessary co-operation of manufacturers and the public in general, there will be released in due season for country wide distribution a statement giving an outline of the entire movement including, if permission is received, in the papers of each State portraits and biographical notes of the State Directors. Prior to this it is obviously desirable that no mention of this work should be made.

February 15th, 1916.

JUNIOR AND STUDENT PRIZES

The members of the Committees on Junior and Student Prizes, consisting of Robert H. Fernald, Chairman of the Junior Prize Committee, Fred E. Rogers and George B. Brand, and Frederick R. Hutton, Chairman of the Student Prize Committee, Robert H. Fernald and D. W. Kimball were reappointed by the Council for the year 1916.

Papers for the Junior Prize, which consists of fifty dollars in cash and an engraved certificate signed by the President and Secretary of the Society, are restricted to the Juniors of the Society. The two Student Prizes consist of twenty-five dollars each in cash and an engraved certificate signed by the President and Secretary and are restricted to enrolled members of the Student Branches in good standing. As no award of the Student Prizes was made last year, it is within the power of the committee to award the accumulated prizes to more than two authors this year, provided the papers in competition are deemed of sufficient merit.

Papers must be submitted before June 30, the committees reporting their recommendations to the Council on or before October 1. It is hoped that a large number of papers will be submitted for the decision of the committees.

NAVAL CONSULTING BOARD

One of the most important meetings of the Naval Consulting Board yet held was that which convened at the New York Navy Yard, on February 9. The two representatives of the Society on the Board, Spencer Miller, Member of Council, and W. L. R. Emmet, were among those present.

Reports dealing with the problems of chemistry and physics applied to warfare, steam engineering, internal combustion motors, ordnances and explosives, mines and torpedoes, submarines and other matters vital to the administration and operation of a great navy were submitted by the various sub-committees.

Howard E. Coffin presented in detail the plan approved by President Wilson and worked out by a committee of the Board for the mobilization of the industries of the country.

Thomas A. Edison submitted the complete plans and specifications for the experimental laboratory for the Navy proposed by him at a previous meeting of the Board. The principal buildings provided for in the scheme are an administration building, a chemical and physical laboratory, a machine shop, an erecting shop, a forge building, a foundry, a pattern shop, a sheet metal shop and a power house.

Mr. Edison stated that the purpose of the design was to obtain quick work and thorough and efficient results. He said that in the laboratory a submarine engine, which now takes six months to build, could be completed in not more than six days.

Thomas Robins supplemented Mr. Edison's remarks, and said that the laboratory will afford a place for the testing of new devices without subjecting the vessel on which they are to be placed to any possibility of damage.

A BUSY PERIOD

The Engineering Societies Building in New York is a place of great activity during a large part of the winter season. Last month, especially, has witnessed very notable gatherings which have been largely attended and at which there was a full measure of enthusiasm. Three of these have been the conventions of the Illuminating Engineering Society, the American Institute of Electrical Engineers and the American Institute of Mining Engineers.

The midwinter convention of the Illuminating Engineeirng Society was held on February 10 and 11. This convention celebrated the tenth anniversary of the Society, which was signalized by the conferring of honorary membership on Thomas A. Edison, Hon.Mem.Am.Soc.M.E. The presentation was made by John W. Lieb, Mem.Am.Soc.M.E.

The fourth midwinter convention of the American Institute of Electrical Engineers was held on February 8 and 9. There were four technical sessions and a dinner-dance. The program was of a diversified character, the papers including communications on Municipally Operated Electric Utilities of Western Canada, by A. G. Christie; operation of the Norfolk & Western Railway, by F. E. Wynne, and Chattering Wheel Slip in Electric Motive Power, by G. M. Eaton.

The American Institute of Mining Engineers held its annual meeting February 14 to 17. Sessions were held on petroleum and gas; coal and coke; mining, conservation and non-metallic minerals; precious and base metals, and iron and steel. The reception and annual dinner were held at the Hotel Astor, and other features of the convention were excursions, alumni reunions, and a smoker.

Among the twenty-nine papers presented were the following

by members of our Society: Development of the Law Relating to the Use of Gas Compressors in Natural Gas Production, Samuel S. Wyer; Application of Electric Power to Mining Work in the Witwatersrand Area, South Africa, J. N. Bulkley; Manganese-Steel Castings in the Mining Industry, Walter S. McKee; Wasted Metal, Henry D. Hibbard and Edward L. Ford, and Manufacture and Tests of Silica Coke-Oven Brick, Kenneth Seaver.

The climax in the month's series of meetings, however, was the first of the military lectures for engineers which are elsewhere announced. This lecture was coincident with the meeting of the American Institute of Mining Engineers and more than 2300 engineers attempted to get into the auditoriums of the Engineering Societies Building to hear the speakers. An overflow meeting was held in the second largest hall in the building and several hundreds were turned away at the doors. Even the committee which arranged the lecture was astonished at the interest displayed and now three lecture courses have been organized to take care of the crowds that desire to attend.

COST OF ELECTRIC POWER

In response to an invitation from the American Institute of Electrical Engineers, the President was authorized to appoint a committee of five to coöperate with the American Institute of Electrical Engineers and similar committees of other societies on the determination of the cost of electric power. The following members of the Society were appointed: D. C. Jackson, A. H. Kruesi, R. J. S. Pigott, John A. Stevens and B. F. Wood. The National Electric Light Association and the American Electric Railway Engineering Association have also appointed committees to coöperate with the Electrical Engineers and our Society, and the first meeting of the joint committee was held February 9. Henry G. Stott was elected chairman and W. S. Gorsuch secretary of the joint committee.

LECTURES ON MILITARY ENGINEERING

Courses of free lectures on military engineering, organized by a group of engineers in coöperation with officers of the United States Army, are now being delivered in the Engineering Societies Building and in the building of the American Society of Civil Engineers, New York. Originally one course of seven lectures on Monday evenings during February and March was planned, and invitations to attend were extended to all engineers in New York and vicinity, but the number of applicants for admisison was so great that a second, and finally a third course had to be provided. This leads the committee to think that if similar courses could be arranged for in Local Section centers and elsewhere, they would be well attended by members who would in return receive the benefit of valuable information upon this important subject.

The topics of the lectures in New York include organization of engineers in war, the service of reconnaissance, fortifications, defences, lines of communication, camps and cantonments, military railways, etc. The lecturers are Captains Thomas M. Robins, Richard T. Coiner and Edward P. Ardery, Corps of Engineers, U. S. A.; and the Committee of Arrangements includes the following members of our Society: J. Waldo Smith, *Chairman*, Gano Dunn, W. L. Saunders, Bradley Stoughton, D. S. Jacobus, Calvin W. Rice, George Gibbs, Alex. C. Humphreys, John W. Lieb and W. H. Wiley. The Secretary of the committee is J. S. Langthorn, 250 W. 54th Street, New York City.

GREETINGS TO MINING ENGINEERS

On the occasion of the annual gathering of the American Institute of Mining Engineers, representing the President, Dr. Jacobus, Prof. Frederick R. Hutton, Honorary Secretary, Am.Soc.M.E., was the bearer of fraternal greetings and cordial good wishes from our Society.

Professor Hutton delivered an appropriate and timely address, the keynote of which was the natural bond between mining and mechanical engineers and a cogent plea for the strengthening of this bond in working out ideals of service to the country in these times of preparedness.

Opening aptly with the quotation from Robin Hood:

> The sword is a weapon to conquer fields,
> I honor the man who shakes it;
> But nought is the lad who the broadsword wields,
> Compared to the lad who makes it.

Professor Hutton showed how the mining engineer Lads "made" iron and steel, copper and other metals, without which the mechanical engineer could not "shake" the tools of his trade, while the mechanical engineer Lads made for the mining engineer his power plant and his hoisting machinery without which his work would have progressed but slowly.

Regarding defense, he said that the five factors to be considered are: 1, men; 2, fighting machines, artillery and tools; 3, transportation; 4, communications; 5, supplies, and that the engineer will be the dependence of the military arm in four. Since in preparations for defense engineers will have to come together more and more, he advocated us being already together.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION

The ninth annual convention of the National Society for the Promotion of Industrial Education was held in Minneapolis, Minn., on January 20-22, 1916, and William H. Kavanaugh, Mem.Am.Soc.M.E., was in attendance as Honorary Vice-President of the Society. The opening session was presided over by the Hon. William C. Redfield, U. S. Secretary of Commerce, and president of the organization. The principal paper of the session was presented by David Snedden, Commissioner of Education for Massachusetts, who urged compulsory vocational education. The session on the 21st was given over to a study of the recently completed industrial survey of Minneapolis. This survey was made possible by a trust fund of more than $5,000,000 left by the will of the late William Hood Dunwoody for purposes of industrial education. Before undertaking to put into effect the provisions under which this fund was given, the trustees of the fund desired complete information as to the kind of vocational education most needed by the Society of Minneapolis, and facts as to the ways in which they could coöperate with other educational agencies and institutions of the city and state. Early in 1915 the superintendent of schools together with the Board of Education and trustees of the Dunwoody Institute secured the coöperation of various local agencies in asking the National Society for the Promotion of Industrial Education to come to Minneapolis to make this survey and hold its annual convention there. The survey was begun on May 1, 1915, under the direction of the National Society's Survey Committee of which Charles R. Richards, Director of Cooper Union, and Mem.Am.

Soc.M.E., is chairman, and the local Minneapolis Survey Committee with C. A. Prosser, then Secretary of the National Society, as director of the survey. This survey has met with the hearty support of every interest in the city. The report of this survey forms Bulletin No. 21 of the National Society for the Promotion of Industrial Education, and covers nearly 700 pages. At the meeting, Dr. Prosser explained in detail the circumstances attending the projection and making of the survey, and C. R. Richards discussed in a general way the recommendations of the survey. Recommendations bearing on special phases of the report were discussed by various speakers.

The session on January 22 included a series of talks on various phases of industrial education, one of the most interesting of which was by Dr. G. E. Barnett of Johns Hopkins University, who spoke on the Possibilities and Accomplishments of Trade Agreement in Industrial Education. The convention was brought to a close by the business meeting, at which a resolution, endorsing the Smith-Hughes bill, which provides for federal aid to industrial education, was passed. It was the unanimous opinion of those in attendance that the industrial survey of Minneapolis was by far the most important feature of the meeting. Charles Richards is quoted as saying that the survey gives Minneapolis something to build on, and is the best asset any city ever gained for itself; it will save hundreds of thousands of dollars in avoiding mistakes.

ANNUAL DINNER OF BOSTON ENGINEERS

The engineers of Boston scored another triumph in their plan for coöperative meetings, on the occasion of the seventh annual banquet of the Boston Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, held on February 8, 1916. More than 500 engineers were present.

Charles L. Edgar, president of the Edison Electric Illuminating Company of Boston, acted as toastmaster. The speakers were Governor Samuel W. McCall, of Massachusetts; Col. W. E. Craighill, of the Corps of Engineers, U. S. A.; William Barclay Parsons, Chairman of the Joint Committee of the National Engineering Societies appointed in connection with the formation of a Reserve Corps of Civilian Engineers; our Past Presidents John R. Freeman and Dr. John A. Brashear, and our Secretary, Calvin W. Rice.

With a list of speakers so closely identified with affairs of national importance, the addresses inevitably touched on certain of the great problems now before the country, particularly upon the subject of preparedness, and the proposed reserve corps of engineers.

The first speaker was Governor McCall, who spoke of the expansion of the science of engineering along scientific and economic lines, and of the service which engineers might thereby render to the state.

Mr. Rice, as representative of the national engineering societies, responded to the address by Governor McCall on The Engineer and the Commonwealth. He stated the various ways in which the societies are coöperating, illustrating that the movement of which Boston is such a fine example is not only spreading through the societies, but is the custom of the parent societies. Referring to industrial preparedness, he announced that the directors of the census for this movement would be appointed in the near future and to their duties would be attached great honor and importance.

Colonel Craighill spoke of the duties of engineers in national defense, saying that in the course of war, should Boston be attacked, it would require 25,000 men, working 10 days, to build 80 miles of trenches, at a cost of $2,000,000, this being requisite to protect Boston properly.

The next address was given by William Barclay Parsons, chairman of the joint committee of the national engineering societies to secure a reserve corps of civilian engineers for the Army. These men would serve, according to his plan, two weeks a year in the army, and hold commissions for five years. This would correspond to the present medical reserve corps.

John R. Freeman made a brief report upon the situation at Panama, where he was one of the three engineer members of the commission recently nominated by the National Academy of Sciences, and appointed by the President to report on the slides.

The closing address of the evening was by Dr. John A. Brashear, on An Evening's Journey Among the Stars.

THE MARCH MEETING OF THE CINCINNATI SECTION

On March 18 the Cincinnati Section will hold a joint meeting with the Engineers' Club of Cincinnati, which will be the most ambitious meeting yet attempted by the Section. It will continue from 2:30 in the afternoon until 10 o'clock in the evening, and at least four papers and possibly six will be presented. The meeting will occur at 25 E. 8th Street, adjourning at 5.30 for dinner at one of the hotels. J. B. Stanwood, chairman of the Section, will preside over the afternoon meeting, and Mr. Stanwood and Frank A. Raschig of the Engineers' Club will preside over the evening session, which will begin at 7:30 p.m. At 9:30 the session will adjourn and a Dutch lunch will be served, during which a further opportunity will be afforded for discussion and for general getting together. All of the members of the Society and their friends are cordially invited to any or all of the sessions. The papers which have been decided upon so far are as follows: Why Is An Engineer, by W. G. Franz, Mem.Am.Soc.M.E.; Volume Control for Motor Driven Air Compressors, by Paul Diserens, Mem.Am.Soc.M.E.; Recent Experiments with Boiler Furnaces, by Prof. John T. Faig, Mem.Am.Soc.M.E.; The Sales Engineer in his Relation to Production and Machine Design, by A. J. M. Baker, Mem.Am.Soc.M.E.; Probable Future Requirements in Machine Tools, by A. M. Sosa, member of the Engineers' Club of Cincinnati. Some interesting papers dealing with machine tools and production methods have also been promised, and a definite announcement of them will appear on the complete program which will be sent out later by the Section.

BUFFALO ENGINEERS TO HELP IN MUNICIPAL AFFAIRS

Last November four councilmen were elected to serve the city of Buffalo under the new commission form of government which has gone into effect in that city, and the engineers of Buffalo have been alive to the possibilities of effective coöperation with the city government in the conduct of the engineering work of the municipality.

On December 15, 1915, a meeting of the Engineering Society of Buffalo was addressed by C. E. Drayer, secretary of the Cleveland Engineering Society, on Engineers in Politics. Three of the councilmen attended this meeting and at the close Councilman Kreinheder, who has since taken charge of the Department of Public Works, indicated his desire to enlist the services of a committee from the Buffalo Society to work in coöperation with him on engineering problems. This meeting, and the paper by Mr. Drayer, stimulated the feeling

that it is incumbent upon engineers to lend their services for the public good, as is now done so extensively by other professional organizations, notably by the American Medical Association and the American Institute of Architects.

On February 2 a second meeting was held, addressed by Morris L. Cooke, acting director of the Utilities Bureau of Philadelphia, on Public Service. There were over 300 engineers present and the meeting aroused much enthusiasm and was given a large amount of space in the daily press of Buffalo.

Following the December meeting mentioned above, the proposed committee to coöperate with the city council was appointed, consisting of John Younger, president of the Engineering Society of Buffalo, David C. Howard and David W. Sowers, all members of The American Society of Mechanical Engineers. Mr. Younger, in a communication to The Journal, writes: "You may be sure that this is only the first step to have our engineering society recognized as one of the factors in civic life. We propose at first that any members having suggestions or ideas send them in to this committee, who will put them in workable shape before transmitting them to the council. We will also have referred to us matters of engineering interest that are the problems of the council and this final committee will, in all probability, appoint some committees, of an investigating nature, who will present their results in the form of reports. Naturally, at first we shall attempt to go slowly and gain the confidence of the council by doing what we are asked, rather than inflicting our presence on them to an unnecessary degree.

I feel sure that this practical outcome of the various lectures that have been delivered during the past year and a half by various members of the Society will be an incentive to the societies in other cities to make still further efforts to have their presence known."

NOTES

The Committee on Meetings is already considering plans for the next Annual Meeting, and desires to announce that papers which are to be contributed should be in hand by September 20, 1916. On account of the time required for all of the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received after the date mentioned are liable to be held over for a later meeting. In view of the fact that the date announced is immediately following the summer season, which is the usual vacation period, the members are urged to prepare papers during the coming spring so far as possible, and to submit them early in the summer.

Last year a group of juniors and seniors in the mechanical engineering course at the University of Illinois met and organized a professional engineering fraternity now known as Pi Tau Sigma. The aim of the society is to foster high engineering ideals, and to promote the mutual welfare of its members. The fraternity has laid plans for a national organization.

The question of the advisability of adopting the metric system as the practical standard in engineering in this country has been brought up by the American Institute of Electrical Engineers. The Institute has invited our Society to appoint two representatives on a joint committee of the national engineering societies to prepare a report upon this important subject. Meanwhile, the Council invites correspondence from members expressing their opinions as to whether this change of fundamental units would be advantageous.

Major William H. Wiley, Chairman of our Committee on the Reserve Corps of Civilian Engineers, reported at the last meeting of the Council that the greatest enthusiasm had prevailed on the part of the House Committee on Military Affairs when the chairmen of the committees of each of the engineering societies presented the plan for an Engineers' Reserve Corps. That such a group of citizens should be desirous of serving the United States without compensation made a deep impression. The committee of our Society consists of Major William H. Wiley, *Chairman*, W. F. M. Goss, H. A. Gillis and Alex. C. Humphreys.

H. J. Freyn, chairman of the Sub-Committee on Gas Power, has called a meeting of that committee in Chicago to make preliminary plans for a Gas Power Session at the next Annual Meeting, and it is expected that meetings of other subcommittees will be held in the near future to make similar plans. A feature of the last Annual Meeting was the large number of papers for which committees were responsible. More than half of the papers read were arranged for and selected by committees of experts in their respective fields. A sustained interest by a wide circle of the membership and authoritative treatment of important subjects are two of the desirable consequences.

At the annual meeting of the Board of Trustees of the United Engineering Society on January 27, Charles F. Rand was elected President, H. H. Barnes, Jr., First Vice-President, H. G. Stott, Second Vice-President, Frederick R. Hutton, Secretary, Joseph Struthers, Treasurer, and Samuel Sheldon, Assistant Treasurer. Henry G. Stott was appointed as the representative of this Society, succeeding Jesse M. Smith; Samuel Sheldon representative of the American Institute of Electrical Engineers, succeeding Charles E. Scribner, and W. L. Saunders, representative of the American Institute of Mining Engineers, succeeding Joseph Struthers.

The papers given at the International Engineering Congress at San Francisco are being published in a series of eleven volumes, each volume comprising contributions to one particular branch of engineering. The Secretary, W. A. Cattell, 425 Foxcroft Building, San Francisco, Cal., announces that volume six on mechanical engineering is now being distributed. This volume contains 18 papers on founding, flanging, tools, boilers, engines, turbines, compressed air, etc., and is handsomely printed. The price is $5.00. While this set of Transactions is sold by subscription, provision is made for a few additional copies for subsequent orders, but the number of such volumes is limited and it cannot be agreed in advance that orders for separate volumes can be filled.

With two large conventions held annually, and meetings of the Society in fifteen different cities between times, a large number of papers come to this office for publication. Occasionally there are papers which cannot be used in The Journal and for all such a file is kept in this office where the papers may be consulted by any one interested. This applies also to appendices of papers, logs of tests and other

detailed information when too voluminous for publication, or when not considered of sufficient general interest for the reader. Often duplicate blueprint copies of such information are available so that any member who is investigating a subject may send to Society headquarters for the additional data.

A meeting to be held at the Bureau of Mines Building, Washington, D. C., has been called for March 4 to complete a permanent organization in memory of the late Dr. Joseph A. Holmes, who was a member of this Society and Director of the Bureau of Mines. A previous meeting was held in January at which a temporary organization was effected and resolutions were passed looking toward the formation of a permanent organization to be known as the Joseph A. Holmes Safety First Organization. Gen. W. H. Bixby of Washington represented Dr. John A. Brashear and this Society at the first meeting.

It is expected that the movement will result in the establishment of an annual award of one or more medals together with honorariums, which will be termed "The Holmes Award," for the encouragement of those originating, developing and installing the most efficient "safety first" devices, appliances, or methods in the mineral industry; and also, special medals for the recognition of personal heroism or distinguished service in the mineral industry. Dr. Brashear is the Society's representative on the Memorial Committee and General Bixby will serve at all meetings of the committee held in Washington.

The heat treatment of steel has resolved itself to quite an extent into a problem of mechanical engineering. The study and analysis of stress and strain set up in heat treatment and the working out of methods and means to reduce these stresses and strains to a minimum, requires mechanical knowledge. Also further analysis of the results of heat treated steel in service requires more than metallurgical knowledge. In other words, the heat treating man and the mechanical engineer must work together. *Steel and Iron, January, 1916.*

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON APRIL 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grade are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The candidates will be balloted upon by the Council unless objection is received by April 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ANDERSON, FREDERICK C., Cons. Engr., Paper & Pulp Mill, Carthage, N. Y.
ATKINSON, GEORGE K., Supt., The Cincinnati Planer Co., Cincinnati, Ohio
BERGEN, HARRY S., Asst. Supt., Toledo Scale Co., Toledo, Ohio
CARR, EDWARD W., JR., Pres., E. W. Carr, Inc., New Orleans, La.
CLARK, GEORGE A., Mech. Engr., Arnold Print Wks., No. Adams, Mass.
DYETT, FRANK J., Mgr., The Frank J. Dyett Co., Ilion, N. Y.
FITZGERALD, THOMAS J., Equipment Engr., Remington Arms Co., Eddystone, Pa.
GALE, HENRY P., Ch. Engr., Oneida Steel Pulley Co., Oneida, N. Y.
HESSLER, GEORGE M., Asst. Genl. Mas. Mech., Wisconsin Steel Co., So. Chicago, Ill.
HINCHEY, H. JNO. O., with Buffalo Forge Co., Buffalo Steam Pump Co., Atlanta, Ga.
KEDY, STILES F., Engr., The Columbia Mills, Inc., Minetto, N. Y.
KENNEDY, ABSALOM M., Staff Engr., Lab. Thos. A. Edison, Orange, N. J.
LUHR, CHARLES W., Supt., Lab. Thos. A. Edison, W. Orange, N. J.
MOLYNEUX, GEORGE E., Inventor, New York
MORRISON, JARED P., Ch. Insptr., Hartford Steam Boiler I. & I. Co., St. Louis, Mo.
MOSES, FREDERICK T., Vice-Pres. and Engr., Firemen's Mutual Ins. Co., of Providence, R. I., Detroit, Mich.
MOSMAN, ERNEST, Mech. Engr., The Subers Fabric & Rubber Co., Cleveland, Ohio
NYE, THEODORE H., Asst. Ch. Draftsman, Morgan Constr. Co., Worcester, Mass.
OKEY, PERRY, Prop., Okey Mfg. Co., Columbus, Ohio
PARKER, LINDSAY R., Engr. Stas., Toronto Hydro-Elec. System, Toronto, Ont., Can.
PAUSIN, HUGO R., Supt. Ord. Dept., E. W. Bliss Co., Brooklyn, N. Y.
PLUMB, FREDERIC H., Mgr. Motor Pump and Eng. Dept., The Standard Supply & Equipment Co., Philadelphia, Pa.
PRATT, EDWARD W., Asst. Supt. Motive Pwr. and Mchy., Chicago & No. Western Rwy Co., Chicago, Ill.
RAMSEY, GEORGE W., Patent Lawyer, Lecturer on Patent Laws, George Washington Univ., Washington, D. C.
SMITH, RODNEY W., Ch. Engr., Board of Education, St. Louis, Mo.
THOMAS, PERCY H., Cons. Engr., New York
TURNBULL, MYRTON J., Cons. Engr., Philadelphia, Pa.
WILLIAMS, EDWARD G., Vice-Pres., the J. G. White Engrg. Corp., New York
WARE, CORVIN E., Mgr. N. Y. Office, Hoppes Mfg. Co., New York
WOODROFFE, GEORGE H., Engr. of Tests, The Parkesburg Iron Co., Parkesburg, Pa.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ARKELL, WILLIAM C., Efficiency Expert, Beech-Nut Pkg. Co., Canajoharie, N. Y.
BATES, HARRY H., Boiler Room Foreman, Norfolk & Western Rwy. Co., Bramwell, W. Va.

BUDWELL, LEIGH, Insptr.,
Norfolk & Western Rwy., Bramwell, W. Va.
COX, JAMES W., JR., Supt.,
The Albany Felt Co., Albany, N. Y.
DAVIS, CALVIN E., Test Engr.,
Amer. Engrg. Co., Philadelphia, Pa.
DYER, PERCY A., Mch. Tool Specialist,
Genl. Elec. Co., New York
EATON, PHILIP B., Naval Engr.,
2nd Lieut. of Engrs., U. S. Coast Guard, San Francisco, Cal.
GAUSS, HENRY F., Asst. Mech. Engr.,
Operating Section, Water Div., Dept. of Public Utilities, St. Louis, Mo.
KRAUS, SYDNEY M., Lieut. (JG), U. S. Navy,
Columbia Univ., New York
SUTTILL, ALBERT G., Ch. Engr.,
James Boyd & Bro., Inc., Philadelphia, Pa.
TRIMMER, JAMES W., Prod. Dept., Estimator,
N. Y. Shipbuilding Co., Camden, N. J.
WARDEN, GUY L., Pwr. Supt.,
E. I. du Pont de Nemours & Co., City Point, Va.

FOR CONSIDERATION AS JUNIOR

ANDERSON, HERBERT W., Mech. Engr. and Insptr.,
Wizard Co., Boston, Mass.
BAILEY, ALTON A., Field Insptr.,
with M. E. Cooley, Appraiser, Newark, N. J.
BARRON, ALEXANDER F., Draftsman,
Amer. Smelting & Refining Co., Maurer, N. J.
BUNZL, WALTER G., Student,
Columbia Univ., New York
CARTER, CHESTER A., Irrigation Engr.,
with Carter Bros., Garden City, Kan.
CROOKS, STANLEY B., Asst. Dist. Supt.,
Prod. Dept., Quapaw Gas Co., Bartlesville, Okla.
DUNN, LESTER S., Engrg. Dept.,
Brighton Mills, Passaic, N. J.
DURYEE, ANDREW B., Mech. Engr.,
Gerstendorfer Bros., New York
FRANKET, WILLIAM F.,
With Remington Arms & Ammunition Co., Derby, Conn.
GELDER, JOHN T.,
with Penn. R.R., Fort Wayne, Ind.
GREENWALD, LOUIS, Student,
Columbia University, New York
HEILEMAN, FRANK A., Foreman, Lt. and Heat Sta.,
Univ. of Mo., Columbia, Mo.
HELANDER, LINN,
with Crucible Steel Co., Midland, Pa.
JOHNSTONE, ROBERT M., Designing Engr.,
Robert Gair Co., Brooklyn, N. Y.
STEPANEK, EMIL, Engr. Tractor Wks.,
Internatl. Harvester Corp. of Amer., Chicago, Ill.
STERLING, CLAUDE H., Draftsman,
Thomas B. Jeffery Co., Kenosha, Wis.
TAYLOR, CYRUS J., Field Insptr.,
with M. E. Cooley, Appraiser, Newark, N. J.
WONG, JEE-KWUN, Student Engrg. and Metallography,
Univ. of Minn., Minneapolis, Minn.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

ARMSTRONG, WILLIAM M., Vice-Pres.,
Corrugated Bar Co., Buffalo, N. Y.
BRENGEL, FREDERICK J., Asst. Supt.,
Safety Car Heating & Lighting Co., Jersey City, N. J.
FITZ, ERVIN M., Elec. Engr.,
Penn. Lines West of Pittsburgh, Pittsburgh, Pa.
MASSEY, GEORGE B., Cons. Engr.,
Geo. B. Massey Co., Chicago, Ill.

PROMOTION FROM ASSOCIATE

BIRDSEY, CHARLES R., Ch. Engr.,
United States Gypsum Co., Chicago, Ill.
CRANE, ARTHUR M., Charge Pressure Filter Dept.,
New Continental Jewell Filtration Co., New York

SUMMARY

New applications	60
Applications for change of grading:	
Promotion from Junior	4
Promotion from Associate	2
Total	66

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOTS CLOSING

FEBRUARY 29 AND MARCH 21, 1916

Average Age of Applicants:

Members	40
Associates	40
Associate-Members	32
Juniors	25

Positions held by Applicants:

Executives, including Presidents, Treasurers, Directors, Members of Firms, General Managers	10
Professors and Instructors	8
Superintendents, Assistants, Mechanical Superintendent, etc	14
Consulting, Contracting and Constructing Engineers	4
Chief Engineers or Assistants	14
Mechanical Engineers, Engineers, Assistant Engineers	28
Chief Draftsmen, Asst. Ch. Draftsmen, Designing Engineers, Estimators	14
Managers, Asst. Managers, Sales Managers, Sales Engineers	36
Other classifications	36
Total	142

GEOGRAPHICAL INDEX

(Applications for promotion from any grade, other than Junior, will be indicated by the initials of that grade)

California
San Francisco—Eaton, P. B.
Connecticut
Derby—Franket, W. F.
District of Columbia
Washington—Ramsey, G. W.
Georgia
Atlanta—Hinchey, H. J. O.
Illinois
Chicago—Birdsey, C. R. (A.)
Hessler, G. M.
Massey, G. B. (J.)
Pratt, E. W.
Stepanek, E.
Indiana
Fort Wayne—Gelder, J. T.
Kansas
Garden City—Carter, C. A.
Louisiana
New Orleans—Carr, E. W., Jr.
Massachusetts
Boston—Anderson, H. W.
No. Adams—Clark, G. A.
Worcester—Nye, T. H.
Michigan
Detroit—Moses, F. T.
Minnesota
Minneapolis—Wong, Jee-kwun
Missouri
Columbia—Heileman, F. A.
St. Louis—Gauss, H. F.
Morrison, J. P.
Smith, R. W.
New Jersey
Bayonne—Molyneux, G. E.
Camden—Trimmer, J. W.
Jersey City—Brengel, F. J. (J.)
Maurer—Barron, A. F.
Newark—Bailey, A. A.
Taylor, C. J.
Orange—Kennedy, A. M.
Luhr, C. W.
Passaic—Dunn, L. S.
New York
Albany—Cox, J. W., Jr.
Buffalo—Armstrong, W. M. (J.)
Canojoharie—Arkell, W. C.
Carthage—Anderson, F. C.
Cazenovia—Davis, C. E.
Ilion—Dyett, F. J.
Minetto—Kedy, S. F.
New York—Bunzl, W. G.
Crane, A. M. (A.)
Duryee, A. B.
Dyer, P. A.
Greenwald, Louis.
Johnstone, R. M.
Krauss, S. M.
Pausin, H. R.
New York (Cont'd.)—Thomas, P. H.
Ware, C. E.
Williams, E. G.
Oneida—Galę, H. P.
Ohio
Cincinnati—Atkinson, G. K.
Cleveland—Mosman, E.
Columbus—Okey, Perry.
Toledo—Bergen, H. S.
Oklahoma
Bartlesville—Crooks, S. B.
Pennsylvania
Eddystone—Fitzgerald, T. J.
Midland—Helander, L.
Parkesburg—Woodroffe, G. H.
Philadelphia—Plumb, F. H.
Suttill, A. G.
Turnbull, Myrton J.
Pittsburgh—Fitz, E. M. (J.)
Virginia
City Point—Warden, Guy L.
West Virginia
Bramwell—Bates, H. H.
Budwell, L.
Wisconsin
Kenosha—Sterling, C. H.
Canada
Toronto—Parker, L. R.

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in the Journal.

Maynard D. Church has been promoted to the position of chief engineer of the Terry Steam Turbine Company of Hartford, Conn. His previous position with the company was that of assistant engineer.

William B. Rawson has accepted a position with the Canfield Oil Company of Cleveland, O., in the capacity of engineer and purchasing agent. He was formerly associated with the Canada Cement Company of Montreal, Canada.

G. L. Kothny has terminated his connection with the Westinghouse Machine Company, Pittsburgh, Pa., and has joined the staff of the C. H. Wheeler Manufacturing Company, Philadelphia, Pa., in the capacity of consulting engineer.

Jiles W. Haney has resigned the position of chief engineer of the Commerce Power Company, Kansas City, Mo., to accept the position of instructor in mechanical engineering at the University of Missouri.

Henry R. Gilson, formerly associated with the National Metal Molding Company, Ambridge, Pa., has entered the employ of the Ross Rifle Company of Quebec, Canada.

Joseph J. Nelis gave a lecture on January 31 to the Nashville section of the Engineering Association of the South on past, present and future steam generation, giving a brief resumé of past and present practice, also the probable future trend in boiler and furnace design. The lecture ended with a strong plea for the coöperation of the Engineering Association of the South in getting the Am.Soc.M.E. Boiler Code adopted in the southern states and particularly in the city of Nashville, which has now under consideration the changing of their building and boiler inspection code.

Reginald Trautschold is the author of an article on Power-House Chimney Design for Bituminous Coal which is published in the February 5 issue of *Coal Age*. Mr. Trautschold has also contributed to this issue a brief article on Central Testing Laboratories for New York City.

J. D. Bowles, superintendent of the electric department of the Springfield Gas and Electrical Company of Springfield, Mo., has been named chairman of a committee of the Association of the Missouri Public Utilities Companies to draft uniform rules and regulations governing the construction of overhead and underground lines maintained by the electric light and traction companies of Missouri.

Arthur M. Greene, Jr., Manager, Am.Soc.M.E., delivered a lecture at The Franklin Institute, Philadelphia, on February 6, on The Development of the Pumping Engine.

Dr. John A. Brashear, Past-President, Am.Soc.M.E., presented an interesting illustrated lecture on Astronomy on February 11, before the members of the Rochester Engineering Society, the Association for the Advancement of Applied Optics, the American Chemical Society and the American Institute of Electrical Engineers, at Sibley Hall, Rochester, N. Y. A dinner before the lecture was served in Dr. Brashear's honor at the Rochester Club.

A. F. Yarrow, Hon.Mem.Am.Soc.M.E., the British shipbuilder, has been created a baronet. Sir Yarrow is head of the firm of Yarrow and Company, Ltd., Glasgow, Scotland, and of Yarrows, Ltd., Vancouver, B. C., and has taken a prominent part in the war in regard to the production of submarines, torpedo boat destroyers, etc., and has recently established an experimental tank at the National Physical Laboratory in England, for the elucidation of propeller problems, for the use of any shipbuilder.

Morgan Brooks presented a paper on Relation of Lighting to Architectural Interiors at the mid-winter convention of the Illuminating Engineering Society held in New York, February 10 and 11.

Municipally Operated Electrical Utilities of Western Canada was the subject of a paper presented by Prof. A. G. Christie at the convention of the American Institute of Electrical Engineers in New York, February 8 and 9.

H. H. Vaughan, president of the Montreal Ammunition Co., Ltd., has been elected a director and a vice-president of the Dominion Bridge Company, Ltd.

A. W. Wheatley, vice-president of the Canadian Locomotive Company, Kingston, Ontario, has been appointed president of the Lima Locomotive Corporation, Lima, O.

W. Trinks has contributed an article on the Features of Rolling Mill Reversing Engines to the February issue of *The Blast Furnace and Steel Plant*.

Col. E. A. Stevens, Commissioner of Public Roads of New Jersey, has been elected president of the American Road Builders' Association. The election took place recently at a meeting of the Association in the Automobile Club of America, New York. The Association is composed of highway engineers and others concerned purely with the practical side of road work, and has a membership of about 800.

H. E. Elrod, consulting engineer of Dallas, Tex., has been retained to investigate the waterworks and electric light plants of Sherman, Tex., for the purpose of increasing their capacities.

William S. Twining, formerly consulting engineer of the Department of City Transit of Philadelphia as the representative of Ford, Bacon and Davis, has been appointed director of that department by Mayor Smith.

Prof. William H. Burr has reached the age of retirement, after 22 years of continuous service as professor of civil engineering at Columbia University, and the Board of Trustees announced on February 7 that his active work at the University will cease at the end of the present academic year.

How to Go After South American Trade is the subject of an article by R. W. Gifford published in the February issue of *Machinery*.

Electrochemical War Supplies by Lawrence Addicks was one of the papers presented at the symposium on Electrochemical War Supplies given at the meeting of the New York Section of the American Electrochemical Society held jointly with the New York Section of the American Chemical Society and the Society of Chemical Industry at the Chemist Club, February 11.

An article on Lining Up American Industries for Defense by William L. Saunders was published in the February 6 supplement of the *New York Times*. The article contained a detailed description of the purposes of the industrial committee to be appointed as a coöperative part of the Naval Consulting Board of which Mr. Saunders is a member, and also a discussion of the independence of this country on the Chilean nitrate field for the raw material for the manufacture of nitric acid, which is the base of all military explosives.

A. A. Potter is the co-author with S. L. Simmering of an article on Economics of Stoker, Economizer and Superheater which appears in the February 12 issue of the *Electrical World*. The article deals with points to be considered when selecting and installing apparatus to improve boiler room operations, including possible benefits and cost in the average plant.

Emerson McMillen, president of the American Light and Traction Company, New York, has given a second scholarship in the engineering department of the University of Detroit.

Harry J. Klotz presented a paper on Boiler Efficiency at the 15th annual convention of the Illinois State Electrical Association, held at Champaign, Ill., February 23 and 24. At this convention papers were also presented by J. Paul Clayton on Electric Cooking and by Morgan Brooks on Making Rates for Towns of 2500 and under.

Among the papers read at the annual meeting of the Central Electric Railway Association on February 24 and 25 at Dayton, O., was one by J. Rowland Brown on Gas-Weld Rail Bonding.

George L. Wall has resigned as vice-president and manager of the Lima Locomotive Corporation, Lima, O., to devote his attention to the chairmanship of the sub-committee of the American Railway Association on designs and specifications for proposed standard box cars.

William F. Lathrop has become connected with the Woodmansee-Davidson Engineering Company of Chicago, Ill., in charge of their Milwaukee office. He was formerly in the employ of the Milwaukee Electric Railway and Lighting Company, Milwaukee, Wis., as assistant to chief engineer of power plant.

Louis M. Zach has accepted a position in the engineering department of the International Smelting & Refining Company at Toeele, Utah.

John W. Morton has become associated with the Semet-Solvay Company of Syracuse, N. Y., in the by-product department. He was formerly with the McIntosh and Seymour Corporation, Auburn, N. Y., in the capacity of designer.

Robert M. Hale, until recently with the U. S. Smelting Company of Kansas City, Mo., as construction engineer, has entered the employ of the J. B. Kirk Gas and Smelting Company, Iola, Kan., as chief engineer.

Glen B. Hastings, Chicago, Ill., has been appointed representative of Hamilton and Hansell of New York, for the sale of the Rennerfelt electric furnace in the states of the middle west.

Waldo H. Marshall, president of the American Locomotive Company and first vice-president of the Merchants' Association of New York, has been appointed to the executive committee of the Merchants' Association succeeding Irving T. Bush.

Notes on Electric Power Development presented by E. M. Herr at a meeting of the Railway Club of Pittsburgh, is published in the February 1 issue of *Practical Engineer*.

John E. Muhlfeld presented a paper on Pulverized Fuel for Locomotives at the February 18 meeting of the New York Railroad Club in New York.

George W. Bacon of the engineering firm of Ford, Bacon and Davis, New York, has joined the export department of J. P. Morgan and Company. Although retaining his connection with the engineering firm, Mr. Bacon will devote all his time to the Morgan interests, the export department of which is engaged in buying supplies for the Allies.

George Gibbs was elected vice-president of the American Institute of Consulting Engineers, February 2.

Sanford E. Thompson presented a paper on Need Accurate Estimates Based on Unit Costs at the February 14 to 17 convention of the American Concrete Institute held in Chicago.

An address on Public Duties of an Engineering Society was given by F. H. Newell at the 21st annual meeting of the Minnesota Surveyors and Engineers' Society held at St. Paul, February 10 to 12.

Julio F. Sorzano, President of the Pan-American Chamber of Commerce, and Alexander C. Humphreys, Past-President, Am.Soc.M.E., and President of Stevens Institute of Technology, have been elected by the New York Chamber of Commerce as members of its Standing Committee on Commercial Education, to serve until May 1918 and 1919, respectively.

J. Wallace Taylor has accepted a position with the Invincible Machine Company, Walkerville, Ontario, Canada, as superintendent. He was until recently affiliated with the Harris Automatic Press Company, Niles, O., in the capacity of chief engineer.

R. A. Lee has been appointed special engineer of The Barrett Manufacturing Company, New York, being head of the department devoted to distillation work. His former position with the company was in the manufacturing department as engineer.

A. H. Fox Gun Company of Philadelphia, Pa., have added to their organization Conrad V. Hahn, formerly instructor in engineering at Temple University and University of Pennsylvania, and until recently affiliated with the Bell Telephone Company of Pennsylvania in the traffic engineering division. He will be assistant to the vice-president and have charge of one of the Philadelphia plants.

James D. Andrew, superintendent of the station engineering department of the Edison Electric Illuminating Company of Boston, Mass., is now on leave of absence in Chile where he will make a report on the 40,000-kw. power plant of the Chile Copper Company, the owners of which are considering making a large extension.

Peter Junkersfeld spoke before the Monday Luncheon Club of the Chicago Telephone Company, February 14, on Electric Service in Chicago.

A. Lewis Jenkins is the author of Formulæ and Alignment Charts for Taper Press Fits, which appears in the February 17 number of the *American Machinist*.

A New Electro-Hydraulic Shovel by Frank H. Armstrong, presented at the February meeting of the American Institute of Electrical Engineers, is published in the February 17 issue of the *Iron Trade Review*.

Guy L. Bayley has contributed an article on the Design of Million-Volt Experimental Transformer to the February 19 issue of *Electrical World*. This article deals with the construction and operation of an unusual type of high-tension unit displayed at the Panama-Pacific International Exposition.

NECROLOGY

ALFRED WILLIAMSON

Alfred Williamson was born in New York City on July 12, 1880. His early education was received in the public schools of New York City, after which he took a course in mechanical engineering at Columbia University, graduating in 1902. He then entered the service of the New York Central and Hudson River Railroad Company as a special apprentice in their West Albany shops. In 1904, he was employed in the turbine construction department of the General Electric Company in Schenectady, N. Y., but in 1905 he returned to Columbia and took up post-graduate work. In the latter part of that year, he was employed on the work of the Metropolitan Street Railway Company, but in the following year he entered the employ of the Department of Water Supply of New York as a mechanical engineer. From 1910 he was in charge of the pumping stations, Manhattan and the Bronx.

Mr. Williamson became a member of this Society in 1902. He died at his home in Bronxville, N. Y., on December 26, 1915.

LUCIEN MAXWELL BRIGHAM

Lucien Maxwell Brigham was born in Brooklyn, N. Y., on June 6, 1874. He received his education in the schools of Brooklyn. Mr. Brigham's entire business career was with the firm of Maxwell, Manning and Moore, in which firm he first became an employee in 1894. He acted in the later years of his life in the capacity of sales manager of the brass goods department, and during the last five years he was a member of the board of business associates in the carrying on of his department.

Mr. Brigham was a member of the Engineers' Club, the Railroad Club, and several social clubs. He became a member of this Society in 1906. Mr. Brigham died at his home in Orange, New Jersey, on December 11, 1915.

WILLIAM F. SARGENT

William F. Sargent was born in New Haven, Conn., on June 27, 1882. He received his education in the public schools of New Haven and the Boardman Training School from which he graduated in 1901. From September, 1901, until May, 1902, he was in the employ of the Winchester Repeating Arms Co. While there his work consisted of mechanical drawing, surveying for new buildings and roads, laying out machines in factory additions and general machine design. In June, 1902, he accepted a position with the Bigelow Company, with which company he was connected until the time of his death. For five years he was chief draftsman and later was made sales engineer and estimator. Mr. Sargent became a member of this Society in 1914. He died at his home in New Haven on December 7, 1915.

JOHN ALEXANDER HILL

John Alexander Hill, president of the Hill Publishing Company, was born in Sandgate near Bennington, Vermont, on February 22, 1858. His parents very soon after moved to central Wisconsin, and it was there that he received his early education. When he was 14 years of age, Mr. Hill started work in a country printing office and later became half owner of a machine shop. In 1878 he removed to Colorado and ran a locomotive on the Denver & Rio Grande R. R. He was soon made a roundhouse foreman and later assistant superintendent of motive power.

Mr. Hill had a great fondness for journalism and in 1885 he founded the Daily Press of Pueblo, Colo. At this period he contributed a number of articles to Locomotive Engineering, published in New York by a company which also published the American Machinist. In 1888 Mr. Hill was invited to come to New York and take charge of Locomotive Engineering. Shortly after this he associated himself with Angus Sinclair, purchased the journal from its owners, and undertook to carry it on as a separate publication. In 1896 Mr. Hill sold his interest in Locomotive Engineering and purchased the American Machinist. Mr. Hill later bought other publications, including Power, Engineering and Mining Journal, Engineering News, and Coal Age. To carry on these various publications he organized the Hill Publishing Company.

The printing and publication of the company's magazines is all carried out in one building which was completed in 1914 and was planned and built not only to suit the convenience and economy of the printing and publishing business but also to provide for the safety, comfort and health of the army of workers housed in it.

Mr. Hill was Vice-President of the Machinery Club, member of the Engineers' Club of New York City, and Railroad Club, and Campfire Club. He became a member of this Society in 1913. Mr. Hill died on January 24, 1916.

WILLIAM BARKER RUGGLES

William Barker Ruggles was born in Bath, N. Y., on December 17, 1861. He received his early education in Bath, and graduated from Cornell University in 1883. He then became associated with the West Shore Railroad, working at Frankfort, N. Y., and elsewhere, and later with the American Casualty Company. In 1893 he founded the Ruggles-Coles Engineering Company. He was the inventor of the Ruggles-Coles double-shell dryer and was president of the Ruggles-Coles Engineering Company up to the time of his death. He was also president of the Novella Cement Company, Niagara Cement Company, and a director of the Buffalo Potash and Cement Corporation.

Mr. Ruggles was a member of the Engineers' Club, the Machinery Club, the Psi Upsilon and Cornell University Clubs of New York and a trustee of Trinity Church of Bayonne, N. J. He became a member of this Society in 1905. He died at his home in Bayonne, N. J., on January 23, 1916.

GEORGE HARWOOD CUSHING

George Harwood Cushing, superintendent of the North and South plants of the H. B. Smith Company of Westfield, Mass., was born in Worcester, Mass., on October 13, 1860. He graduated from the Worcester Polytechnic Institute in 1884. For a number of years he was assistant superintendent of the H. B. Smith plants, was superintendent of a pump plant at Seneca Falls, N. Y., for thirteen years, and was in charge of a foundry at Montreal, Canada, for two years. In 1906 he returned to the H. B. Smith Company at Westfield.

Mr. Cushing became a member of this Society in 1891. He died at his home in Westfield on January 6, 1916.

PAUL G. ROESTI

Paul G. Roesti was born in Berne, Switzerland, in April, 1878. He received his early education in the public schools of his native city. After graduating in mechanical engineering from the technical school at Berne, Switzerland, in 1896, he was employed for two years in the engineering offices of Frickart in Munich, Bavaria, and one year with Sulzer Bros. in Winterthur, Switzerland, working on Corliss and poppet valve steam engines.

In 1899 he entered the Swiss Technical High School at Zurich, Switzerland, from which he graduated in 1903. He then came to this country and was employed by the Buffalo

Forge Company as a designer of steam engines, centrifugal pumps and blowers. In 1904 he took a position with Beckstrom Smith Steam-turbine Co. and Filer and Stowell Company as mechanical engineer and designer of steam turbines and steam engines, remaining with them until 1907 when he became a designing engineer with A. O. Smith Co., Milwaukee, manufacturers of automobiles. He was later made chief engineer of this company.

In 1911 he returned to Switzerland to accept a position with Sulzer Bros. as chief designer in the high-speed Diesel engine department, and he there designed and standardized several new types of engines. He gave up this position in 1915 on account of poor health. He died in California on December 23, 1915.

Mr. Roesti was a member of the German Engineers' Society, and the Swiss Engineers' and Architects' Society. He became a member of this Society in 1914.

AUSTIN D. MIXSELL

Austin D. Mixsell was born in Easton, Pa., on October 20, 1873. He received his education in the schools of Easton and at the Penn Charter School in Philadelphia. He went to Bethlehem in 1892 and was employed in the freight office of the Lehigh Valley R.R. In 1898, he entered the employ of the Bethlehem Steel Company, working in the general superintendent's office and in the sales department, and later was made the representative of that company in New York City. In 1909, he was appointed general sales agent of the Company and in 1915, was elected a vice-president. At the same time, he became a member of the Board of Directors of the Company. He was also president of the Dietrick and Harvey Machine Co. which became a subsidiary of the Bethlehem Steel Company.

Mr. Mixsell was a member of the Bethlehem Club, Bethlehem, Pa., the Union League Club, Philadelphia, the Manufacturers' Club, Philadelphia, the Engineers' Club, New York, the Railroad Club, New York, the American Society for Testing Materials, the American Iron and Steel Institute as an Executive member, and the American Steel Foundries Society. He became a member of this Society in 1913. He died at his home in Bethlehem on January 15, 1916.

GARRETT W. SIMPKINSON

Garrett W. Simpkinson was born in Cincinnati, Ohio, on August 17, 1860. He received his early education in the schools of Cincinnati and later was instructed privately in certain branches of engineering. He served four years as pattern maker and four years in the drafting department of the Lane & Bodley Co. He then entered the employ of The Stilwell and Bierce Mfg. Co., Dayton, Ohio, in charge of the drafting and pattern departments. Several years later, he returned to Cincinnati to assist in building the first cable railway in that city, designing track and curve constructions as well as the mechanical details of the driving stations. After the completion of this work, he returned to the Lane & Bodley Co. and for a time had charge of their drafting department and pattern shop. In 1888, he became associated with Bert L. Baldwin, Mem. Am. Soc. M. E., in designing and constructing inclined plane and electric railways and plants in and near Cincinnati and made a specialty of machine shop and foundry design and construction, as well as structural and architectural engineering. He became a member of the firm in 1900.

For several years, Mr. Simpkinson instructed evening classes in mechanical drawing and mechanics of engineering at the Ohio Mechanics Institute, Cincinnati, Ohio. He was a member of the Cincinnati Engineers' Club and a member of this Society since 1912. Mr. Simpkinson died at his home in Cincinnati on January 22, 1916.

PER H. SCHEDIN

Per H. Schedin was born in September, 1871, in Stockholm, Sweden. He received his education in the Technical School and College of Mining in Stockholm and his mechanical training from the Stridsburg Saw Works, Trolhattan. From 1891 to 1893, he was chemist and foreman in the open hearth department of the Gullofors Steel Works, Sweden. In January, 1894, he accepted a position with the Midvale Steel Company, Philadelphia, starting work in the machine shops and rising to the position of chief draftsman and designing engineer.

Mr. Schedin was a member of the Engineering Society of Western Pennsylvania and of the Midvale Engineering Society. He became a member of this Society in 1913. He died at his home in Nicetown, Philadelphia, on January 22, 1916.

HOLSTEIN DE HAVEN BRIGHT

Holstein De Haven Bright was born in Philadelphia, Pa., on June 30, 1880. He was educated at the William Penn Charter School in Philadelphia and then entered The Baldwin Locomotive Works as an apprentice. He rose rapidly and in a few years was placed in charge of the upkeep of the works. He was then transferred to be assistant secretary of the Standard Steel Works Company, a subsidiary of The Baldwin Locomotive Works. He also organized the sales department of the subsidiary company.

In 1912, he resigned to accept the presidency of the Southwark Foundry and Machine Co., Philadelphia, which position he held until 1914, when he retired because of ill health. He died in Philadelphia on November 2, 1915.

Mr. Bright was a member of the Union League and Meridian Clubs in Philadelphia and the Merion Cricket Club. He became a member of this Society in 1905.

FRANK HASTINGS VARNEY

Frank Hastings Varney was born at San Jose, California, on September 15, 1872. His parents later moved to San Francisco where he received his public school education and where his business life commenced. His engineering work began in 1894 when at the age of twenty-two he became engineer of the Harbor Light & Power Co., a position which included practically all duties from lineman to manager of the 25 kw. station and lighting system. The following year, this concern was absorbed by the Edison Company and he was transferred to the new Stevenson Street plant of that company, by 1898 advancing to station foreman. The plant was then purchased by the San Francisco Gas & Electric Company and he was made chief electrician in charge of their three local steam electric generating stations. In 1900, Mr. Varney was made superintendent of all steam and electric stations, and the distributing system. When this rapidly growing company absorbed the Independent Company, he was made superintendent of generating stations and sub-stations, and the company later becoming part of the Pacific Gas & Electric Company, Mr. Varney was in 1907 made chief engineer of operating and maintenance of steam stations, which position he held at the time of his death. It is interesting to note that in his last position he had control of an output of 90,000 kw.

Mr. Varney became a member of the Society in 1909 and was a member of the American Institute of Electrical Engineers, the National Electric Light Association, and the Engineers' Club of San Francisco. He died at his home in San Francisco on January 21, 1916, after several months' illness.

SOCIETY MEETINGS

IT is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

NEW YORK, JANUARY 11

At the January meeting of the New York Local Section Walter N. Polakov presented a paper on Standardization of Power Plant Operating Costs, which attracted unusual interest, there being nearly 400 in attendance at the meeting. The purpose of the paper was to outline a method by which the owner of a power plant can, without the necessity of study of technical details of operation, judge how close the actual performance of the plant is to the possible minimum cost at any time and under any circumstances. Mr. Polakov, in his experience in power plant operation, has developed a very interesting method of power plant accounting, in which all variable factors beyond operating control are automatically adjusted, and the result is that his methods of standardization of costs offer some interesting advantages.

This meeting of the New York Local Section marked the introduction of an important innovation in the local activities of the Society in New York. In the endeavor to develop increased interest in the local meetings among the members in the vicinity, an invitation was extended to a large number of local members to take part in the work by serving as committee members on three sub-committees that were appointed under the New York Local Section Committee. These consisted of sub-committees on entertainment, acquaintanceship and excursions, and a large number responded. Tentative plans were laid for a smoker and an excursion, and possibly some other form of local entertainment in addition to the regular monthly meetings.

MINNESOTA, JANUARY 20

One of the largest and best meetings in the history of the Minnesota Section was held on January 20, in the form of a banquet, which was attended by 116 members and their ladies. O. A. Eberhardt, ex-governor, who had been scheduled for an address, was called out of the city at the last minute, so his place at the speakers' table was taken by George H. Herrold. The principal speaker of the evening was Charles W. Tubby, Chairman of the Minnesota Section, who gave a history of the Minnesota Section and told of some of the future plans of the Section looking towards coöperation with other engineering bodies to promote engineering as a profession. Prof. Wm. H. Kavanaugh spoke interestingly on engineering education and brought out his various points with some very clever Irish stories. C. L. Pillsbury spoke of the value of engineering societies and indicated how they would prove to be a very valuable asset to the professional engineer. Mr. Pillsbury also referred to some of his experiences on appraisal work and his work in Washington, D. C. Max Toltz, on behalf of the Minnesota Section, presented Gebhard Bohn, Sr., with a beautiful leather-covered certificate which was in the form of a testimonial to commemorate the pleasant occasion during the Spring Meeting of the Society in St. Paul-Minneapolis in June, 1914., when Mr. Bohn, while not a member of the Society, entertained the visiting members and guests of the Society at his beautiful summer home at Lake Minnetonka. Mr. Bohn, in a few well chosen words, thanked the Minnesota Section for remembering him in such a unique

Menu Card and Program for Banquet of the Minnesota Section

way and expressed a desire to be present at the future meetings of the Section.

The social features of the meeting were emphasized by the banquet program, and much interest was created by the unusually attractive invitations and combined program and menu cards used at the banquet, which were beautifully drawn with an emblem embracing the Am.Soc.M.E. members' badge and the name of the Society and Section as the central feature. The card containing menu and program is reproduced herewith. The invitation sheet was in the form of a drawing with a similar badge emblem centered at the top, with a modern large heavy duty gas engine on the one side and a heavy Mallet-type locomotive on the other. Both of these cards were distributed in blue-print form.

CINCINNATI, JANUARY 21

A joint meeting of the Engineers' Club of Cincinnati and the Cincinnati Section of The American Society of Mechanical Engineers was held on January 21. The Committee on Concrete, consisting of eight members who have been work-

ing for about eight months, presented a report of its investigations. The report detailed an investigation of five different sorts of beams of full size as ordinarily used in construction of supporting floor slabs. Various methods for reinforcing these beams were used. A testing machine was devised by which loads of 100,000 lb. and upwards could be applied at the center of these beams. During the progress of each test the beams were calcined and the surfaces examined very closely with reading glasses to discover cracks. As soon as a crack was discovered, it was marked and the load corresponding to the crack was indicated. The tests showed remarkably high values and the report caused a vigorous discussion on the advisability of raising the safe loads for concrete beams.

An investigation dealing with concrete made up of materials found in the vicinity of Cincinnati was detailed by Prof. C. C. Myers, Mem.Am.Soc.M.E. and a member of the Concrete Committee. This portion of the report was particularly interesting to the members because it gave definite and carefully determined values for the various materials that may be obtained in the vicinity of Cincinnati at reasonable prices. One of the results that was shown with remarkable clearness was the great advantage to be derived from properly graduating in size the sand and gravel.

BIRMINGHAM, JANUARY 26

An informal meeting in the form of a dinner was held by the members of the Birmingham Section on January 26. Letters were read and discussed concerning the appointment of a member to the Naval Board; concerning the routing of trains suggested by Mr. Rice to bring those from the East through Birmingham; concerning the appointment of a delegate for the nominating committee; and an announcement of the territory which had been assigned to the Birmingham Section by the Membership Committee to comprise the district from which they can draw new members for the Section. The question of the entertainment of the visiting members on their way to New Orleans was discussed, and the members of Birmingham are more than glad and ready to show their visiting members how to spend a very pleasant and profitable day in Birmingham.

PROVIDENCE, JANUARY 26

The January meeting of the Providence Association of Mechanical Engineers was held on January 26 in the Engineering Building of Brown University. Franklin H. Wentworth, Secretary of The National Fire Protection Association, spoke on the work of the Underwriters' Laboratories in the direction of fire protection. He spoke of the enormous waste in this country from fire, and referred to the growth of the understanding of the need of fire protection. His talk was illustrated by moving pictures showing the workings of the Underwriters' Laboratories.

BUFFALO, FEBRUARY 2

A meeting of the Engineering Society of Buffalo was held on February 2, at which Morris L. Cooke, Mem.Am.Soc.M.E. and for four years Director of Public Works in Philadelphia, gave an address on Public Service Problems. His address dealt with questions relating to the advisability of establishing in Buffalo a municipal asphalt plant, means of preventing waste of water, electric light rates and other municipal problems. After a free discussion, these questions were referred to a city affairs committee, consisting of John Younger, president of the Engineering Society of Buffalo, David C. Howard and David W. Somers. This committee is to act as a clearing house for all suggestions and complaints of members relating to city affairs; to give its services in conference with any of the departments that make up the commission government; to furnish to the city government sub-committees to act without compensation in consulting or investigating capacities.

Mr. Cooke then spoke of the engineering profession and its relation to public service. He said that he was the first engineer to be the director of public works in Philadelphia, and that his successor is also an engineer, and that of the 70 city managers in Philadelphia nearly all are engineers.

A number of lantern slides followed showing how various municipal activities in Philadelphia were advertised during the administration of Mr. Cooke.

ST. LOUIS, FEBRUARY 6

A joint meeting of the local engineering societies was held on February 9, with an attendance of 105. F. W. Doolittle, Consulting Engineer of New York City, spoke on the Cleveland Street Railway situation. His paper was illustrated and brought out considerable interesting discussion.

BIRMINGHAM, FEBRUARY 7

A meeting of the Birmingham Local Section was held on February 7, at which the following committees were appointed: Executive Committee: R. E. Brakeman, *Chairman;* C. B. Davis, Vice-Chairman; Paul Wright, Secretary-Treasurer; F. G. Cutler and J. Henry Klinck, members; Committee on Program and Papers; J. Henry Klinck, *Chairman;* Richard Faull, E. B. Van Keuren, M. J. Lide; Membership Committee: C. B. Davis, H. A. Moon, W. L. Rouche, C. D. Barr and O. G. Thurlow, members.

After some general discussion, Major General Leonard Wood spoke on Preparedness and the coming Military Training Camp to be held at Chattanooga this coming summer.

BOSTON, FEBRUARY 8

The seventh annual banquet of the Boston Section of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers was held on February 8. About 600 members were present and the meeting was unusually successful in every way. The speakers were His Excellency Samuel W. McCall, Governor of Massachusetts; Col. W. E. Craighill of the Corps of Engineers, U.S.A.; William Barclay Parsons, Consulting Engineer, New York City; John R. Freeman, and Dr. John A. Brashear, Past Presidents of the Am.Soc. M.E., and Calvin W. Rice, Secretary of the Am.Soc.M.E.

NEW YORK, FEBRUARY 8

An unusually large attendance marked the February meeting of the New York Local Section, at which T. Russell Robinson, statistical engineer for W. S. Barstow & Co., Inc., New York, read a paper on Ways of Presenting Data for Executive Purposes. Mr. Robinson takes the position that all the data which the engineer can gather on costs, performance of equipment, output and other information of industrial interest, are of little use in securing appropriations from directors, or investments from financiers, until he can present his findings in a way that can be comprehended. He showed in an interesting manner how effective graphical

methods are for this purpose and he proved that graphical methods are applicable to practically all forms of data presentation. The paper was illustrated by lantern slides and drew out an extended discussion.

This meeting was the first in which the newly-appointed sub-committees of the New York local committee on entertainment, acquaintanceship and excursions were brought actively together. In order to bring the local members into closer relationship, the acquaintance committee arranged for an informal dinner preceding the meeting of the evening at which about 125 were in attendance. This was effective in bringing the new committee closely into touch with their work, and at the dinner plans were laid for an active campaign for developing interest in the New York local meetings. Over 400 were in attendance at the meeting of the evening.

ST. LOUIS, FEBRUARY 9

On February 2, there was a joint meeting of the Engineers' Club of St. Louis with the local societies. J. B. Marcellus, engineer of the Association of the American Portland Cement Manufacturers, spoke on Recent Practice on Concrete Roads. His talk was illustrated by several slides and motion picture reels. There were 62 present.

MILWAUKEE, FEBRUARY 10

A meeting of the Milwaukee Engineers' Society which represents the local engineering society, The American Institute of Electrical Engineers, The American Society of Mechanical Engineers and The American Chemical Society, was held on February 10 under the auspices of the Milwaukee Section of the American Institute of Electrical Engineers. Arthur Simon, Mem.Am.Soc.M.E., and electrical engineer of the Cutler-Hammer Mfg. Co., read a paper on The Design and Application of Electro Magnets for Industrial Purposes. He discussed the essential features which determine the design of the magnets and the possible modifications of the design. He showed that the secondary phenomena such as the leakage of the magnetic circuit and the saturation of the iron, very often overshadowed the basic phenomena of electro magnetic induction, and that by properly controlling these factors the characteristics of the magnet can be changed to suit particular purposes.

The speaker also discussed in detail the peculiarities of the alternating current magnet which presents a far more serious problem than the direct current magnet both from the standpoint of mechanical construction and electrical design; the extreme limitations of the alternating current magnet due to hysteresis and eddy-current losses in the iron and to the variation of the self-induction of the magnetic circuit with the movement of the armature. In closing the speaker showed the application of some magnets for heavy current switches which control electric circuits, and also several types of direct and alternating current magnets for brakes such as are used on cranes, elevators and similar apparatus. Moving pictures illustrating the use of a 62 in. lifting magnet in the yards of a steel mill for handling pig iron, scrap, and other material, closed the lecture.

In the discussion structural features of some of the magnets shown were brought out. An interesting application of electro-magnets for shifting the gears of automobiles and the use of magnets for the operation of clutches were discussed. Mention was made of a magnetic clutch transmitting 2000 h.p. at a speed of 100 r.p.m. This is said to be the largest magnet clutch thus far constructed. A buffet lunch at which the discussion was continued informally among the members closed the evening.

MINNESOTA, FEBRUARY 10

The February meeting of the Minnesota Section of the Society was held at the University of Minnesota on February 10, at which George P. Diekmann, chief chemist of the Northwestern States Portland Cement Company, Mason City, Iowa, gave a very instructive illustrated lecture on The Modern Manufacture of Portland Cement. He showed 85 different slides which illustrated the process of manufacture in detail from the time the material is handled by steam shovel to the finished product. His pictures were of unusual interest because they were taken before the Mason City Plant was completed, and in this way gave a better idea of the enormous amount of equipment that is required for cement manufacture.

Mr. Diekmann then discussed the chemical side of Portland Cement. With reference to the various elements that are necessary to produce a good brand of cement, he said that silica lime, alumina and iron must be present in particular ratios in order that a certain chemical action be produced. The ratio of lime to silica should be from (2.8 to 3.2) to 1 and alumina to iron (2.5 to 3.5) to 1. Mr. Diekmann said that the chemical composition of Portland cement is very uniform and is usually as follows: Silica, 20 to 23 per cent; alumina, 5 to 8.5 per cent; iron oxide, 1 to 4 per cent; lime, 60 to 64 per cent; magnesia, 0.5 to 3.5 per cent; sulphuric acid, 1.5 to 2.5 per cent. Mr. Diekmann also spoke of the effects that each element has on the setting of cement and formulae that might be used for calculating the proper proportions in the raw mixture. Mr. Diekmann's lecture was discussed by about ten of the members present. The main questions raised were about the methods of sampling and testing cement residue on the sieves after the fineness test, and the question of value of water-proofing.

BOSTON, FEBRUARY 16

Under the scheme of coöperation existing among the engineering societies in Boston, a meeting was held by the Boston Society of Civil Engineers on February 16. Edward C. Sherman presented a paper illustrated with lantern slides on the Spillways of the Panama Canal.

BUFFALO, FEBRUARY 16

At a meeting of the Engineering Society of Buffalo, on February 16, C. T. Myers, Mem.Am.Soc.M.E., gave a lecture on the Uses of Modern Worm Gearing. Mr. Myers pointed out that worm gearing made by present processes is infinitely superior to the older types, some of which often had the teeth improperly formed. With present day worm gearing, efficiencies of 95 per cent can be readily obtained and the old idea that worm gearing was irreversible has been exploded. Mr. Myers laid stress on the fact that the worm gear had been developed to its present stage by its successful use on motor trucks.

STUDENT BRANCHES

BUCKNELL UNIVERSITY

At the regular monthly meeting of the Bucknell University Student Branch on February 7, Thomas L. James, '16, gave a very interesting talk on Scientific Management of Machine Shops. He discussed the old ways and the new ways of managing a shop, taking an old shop under the old system and converting it into a shop under a new system now in practice. A discussion of the subject followed by Professors Burpee and Kriner. There were 23 members in attendance.

BROOKLYN POLYTECHNIC INSTITUTE

The February meeting of the Brooklyn Polytechnic Institute Student Branch was held on February 11, in the form of a Ladies' Night consisting of a semi-technical lecture illustrated with slides and with moving pictures, and followed by a dance.

Lieut. Percy E. Barbour, C.A.C., N.G.S.M., spoke on Coast Defense. The enormous amount of territory in which the United States is interested was pointed out, and also the fact that the chief source of materials for our explosives are in the Chilean nitrate fields. The natural conclusion was the need of a larger fleet, especially on the Pacific Coast. The slides which followed depicted the types of battleships peculiar to the United States, Germany, and Great Britain. Lieut. Barbour explained that a dreadnought is an all big-gun ship, while the super-dreadnought, the most desirable of fighting vessels, is a battleship possessing a full complement of big guns and, in addition, the guns of the intermediate classes. He also described the working of typical coast defense guns, and gave the audience a good idea of the work of gun crews and range finders by an exposition of the ballistics and methods of range-finding and a description of the Whistler-Hearn plotting boards. The talk was followed by two reels of films which illustrated the pleasure and business of life in the camp at Fort Williams, Me.

The Brooklyn Rapid Transit Company, who donated the use of the moving picture machine, showed a film on Safety First. This is one of the films which this company has used in its campaign to minimize street car accidents.

LELAND STANFORD, JR., UNIVERSITY

The Leland Stanford, Jr., University Student Branch held a meeting on January 26, at which E. B. Anderson, a junior in the mechanical engineering department, gave a talk on the Owen Magnetic automobile. The description was illustrated by a sketch on the blackboard, showing the location of the transmission in the car, the manner in which the armatures of the generator and motor are connected to the propeller shaft, and the position of commutators and ball bearings. After showing the construction, Mr. Anderson explained the manner in which the car is started from rest and brought to full speed by different combinations of field windings and resistances, and the action when pulling up a heavy grade. Among the advantages of this electrical transmission for automobiles which were brought out were easy starting, freedom from gear shifting with its attendant clashing and jerks, great flexibility and smoothness of drive, automatic adjustment of the speed of the car to the grade, ability to climb very steep hills slowly when desired, the reducing of clutch, transmission and starting mechanisms to one unit, and the use of the transmission as a brake by means of a reversing switch. This paper was discussed by J. L. Reynolds, W. H. Warren, J. A. Shepard, H. F. Elliott, G. W. Elsey, E. O. Bennett, H. R. Hammett, H. C. Parker, C. E. Scholtz, and H. E. Waite. In the discussion, the ease of making repairs and the small need of repairing were featured.

THROOP COLLEGE OF TECHNOLOGY

W. W. Smith, chairman of the Los Angeles Section of the Am.Soc.M.E., gave an illustrated talk before the Student Branch of the Throop College of Technology on January 7 on Cooling Water for Condensers. Mr. Smith compared the various methods of cooling condenser water used at present, and gave the limiting factors and difficulties met with in each.

UNIVERSITY OF ARKANSAS

The mechanical engineers of the University of Arkansas met on January 6 and reorganized the Student Branch of the Am.Soc.M.E. The following officers were elected: Prof. B. N. Wilson, honorary chairman; W. G. Horton, chairman; H. A. Coffield, vice-chairman; J. C. Moody, secretary; C. O. Bosemeyer, treasurer. The Branch has decided to hold joint meetings with the Student Branch of the A.I.E.E.

At the first joint meeting on January 18, W. G. Horton gave an illustrated lecture on the advancement of the steam engine. He began with a description of the steam turbine and discussed the various improvements leading up to the modern Corliss and compound engines. Two reels of motion pictures of the Pittsfield, Mass., electrical works were shown by the Electrical Engineering society.

At a meeting on February 1, J. C. Moody gave a paper on the different kinds of lubricants and their properties and the changes which they undergo with increase of temperature. Prof. W. B. Stelzner of the Electrical Engineering Department, in a short address, emphasized the importance of joint meetings of the Electrical and Mechanical societies. He declared that the work of the two classes of engineers are so closely related that an efficient engineer must have at least a general knowledge of both.

UNIVERSITY OF CALIFORNIA

The regular meeting of the Student Branch of the University of California was held on February 8, with an attendance of 17 members.

Three interesting papers were presented, the first by H. Greenwood, on Interior and Exterior Ballistics as Applied to Large Guns, in which he discussed the action of the shot within the gun and also in its path through space. M. Jones discussed the subject of Recoil Chambers on Field Pieces, and Prof. Raber, of the Department of Mechanics, spoke on The Student Engineer and Positions Held by Him, in which he showed the varied character of the positions held by graduates of mechanical engineering colleges.

Following a discussion of the papers presented during the evening, a banquet was held in honor of the new members.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Section was held on January 13. The paper of the evening, which was Rehabilitation of Power Plants, by H. V. O. Coes, Mem. Am.Soc.M.E., was read by Harvey Craig. The paper was illustrated with slides. Forty-two members and guests were present.

UNIVERSITY OF ILLINOIS

The work at the University of Illinois Student Branch started with renewed vigor at the beginning of the scholastic year, and was pushed during the entire semester by the members. This work consisted of a Mechanical Engineering Open House, a series of engineering lectures and the preliminary work on the papers which are to be presented the second semester of the year.

On October 15, 1915, the Mechanical Engineering Open House, which is now an annual affair, was held. All the shops and shop laboratories were in full blast and several interesting processes were performed for the visitors. In the foundry, a heat of cast iron, and several of brass and aluminum were run out, the molds being small ornamental paper weights which were finished immediately and given to the visitors. Three thousand of these souvenirs were distributed in this way. In the machine shops, small sheet metal ash and pin trays were stamped out and die-formed, and in the wood shop an attractive pencil holder was given to each of the visitors. These pencil holders were made by the men in the wood turning classes. An exhibition of different forms of Prest-o-lite welding was done, which proved to be quite an attraction.

In the Engineering Laboratory, the chief attraction seemed to be the artificial snow storm, which was made by mixing saturated air with the exhaust of a compressed air driven engine. Beside this, all the other apparatus of the laboratory was in operation as well as that of the power plant proper.

In connection with the Open House, several reels of moving pictures wholly of an engineering and educational nature were shown. Over 4500 people visited the shops and laboratories, and the Student Branch, as well as the department, consider the Open House quite a success.

At the beginning of the semester the faculty of the Mechanical Engineering Department of the College of Engineering donated a large, handsome silver trophy cup which will be presented to the member of the Branch who presents the best original paper before the Branch during the present school year. The papers will be judged in the following manner: After the paper is presented to the Branch, it will be passed upon by a committee of five of the younger instructors of the University. This committee will choose the five best papers and present them to another committee composed of three of the professors of the College of Engineering who are members of the Am.Soc.M.E. This committee will make the final award.

The series of lectures began on October 21, 1915, with a lecture by Mr. Hower. He took up the features of the sleeve valve motor from an engineering standpoint and gave a most delightfully interesting illustrated talk. About 300 were present. The second of these lectures was on November 4, 1915, given by George L. Willman, who spoke on the business side of engineering. The lecture was well attended and was instructive as well as interesting. On January 13, 1916, O. Monnett gave an illustrated talk on smokeless combustion and the methods of securing it. The last lecture was by W. A. Blonck, who talked on boiler practice in the United States and Foreign Countries. Mr. Blonck had a very complete set of slides which enhanced his lecture greatly.

The work of the next semester will deal largely with the presentation of student papers which have already been prepared, or are now in the process of preparation. An intense rivalry between the upperclassmen seems to indicate that a large number of papers will be entered in the contest for the faculty cup. It is the hope of the Branch that a cup will be donated each year, and there is every reason to believe it will be if the contest this year is a success.

UNIVERSITY OF KANSAS

The Student Branch of the University of Kansas has been meeting weekly at the home of Prof. A. H. Sluss, honorary chairman of the branch. On February 9, Prof. C. A. Haskins, State Sanitary Engineer, and Associate Professor of Civil Engineering, gave a valuable talk on Water Purification. Such gatherings as these, in which every man enrolled in the Mechanical Department is "invited and expected to attend," have been a very material influence in making the Branch grow in interest and numbers to a present membership of 37.

The Automobile Show in Kansas City, February 7-12, brought forth two very interesting talks at the meeting of February 16. B. O. Bower reported on Automobile Engines and C. W. Hagenbuck on Chassis Development.

The Senior inspection trip to Chicago, Gary, and Keokuk afforded sources for an interesting report on the routing system of the Western Electric Co. in Chicago, by S. E. Campbell, and a summary of the tractor manufacturing plant of the International Harvester Co. by J. E. Stillwell.

UNIVERSITY OF KENTUCKY

At a meeting of the Student Branch of the University of Kentucky on February 10 the following papers which have been presented before the Society at the Annual Meeting were read: The Heat Insulating Properties of Commercial Steam Pipe Coverings, by L. B. McMillan, was read by Webb Lail; Circulation in Horizontal Water Tube Boilers, by Paul A. Bancel, was read by J. M. May; Performance and Design of High Vacuum Surface Condensers, by Geo. H. Gibson and Paul A. Bancel, was read by H. P. Parrigin; Proportioning Chimneys on a Gas Basis, by A. L. Menzin, was read by M. S. Sullivan; Higher Steam Pressures, by Robert Cramer, was read by E. R. Pursley. At the conclusion of each article the speaker answered questions on points that were not clear to the members.

At a meeting of the Branch on February 15, L. O. Armstrong of the Bureau of Commercial Economics gave a lecture on Canada.

UNIVERSITY OF MICHIGAN

A meeting of the Student Branch of the University of Michigan was held on January 24, at which the following officers for the coming year were chosen: A. E. Hecker, chairman; T. Toby, vice-chairman; W. F. Gerhardt, secretary; F. M. Sawin, treasurer. These four officers together with one other member elected by them form the Executive Committee.

Twelve members of the Branch were present and discussed plans for increasing the membership and influence of the Branch. A decision was made to provide a "sophomore" session, the general opinion being that the Branch should have more underclassmen, who would thus be available longer for work along the lines they prefer.

UNIVERSITY OF MINNESOTA

On January 22, the University of Minnesota Student Branch held an open meeting in the Auditorium of the Main Engineering Building, at which K. Llewellyn, of the National Tube Company, lectured on the Process of Manufacturing Butt Weld and Lap Weld Steel Pipe. The talk was illustrated with motion pictures, and Mr. Llewellyn took up each process in the manufacture of pipe, from the mining of the ore to the finished product.

UNIVERSITY OF NEBRASKA

At a meeting of the Student Branch of the University of Nebraska in January, Richard Ferguson, manager of the Yankee Hill Brick Company, of Lincoln, Neb., gave a very instructive lecture on Some Engineering Features in Brick Making. The address was so arranged that the development of the science of brick making from the very simplest to the most complicated processes was shown.

Mr. Ferguson first took up the chemistry of brick material, explaining how to select a good clay deposit for the location of a brick factory. He then showed views of the different kinds of brick machines for the dry and wet processes and pointed out the difficulties encountered in the various types of machines. The processes of manufacture, cutting, repressing and drying were explained in detail. The address as a whole showed how closely the work of the mechanical, civil, and chemical engineers is related in brick manufacture. At the close of the lecture Mr. Ferguson gave a general invitation to the University students to inspect the Yankee Hill brickyard at any time.

At a meeting of the Branch on February 8, at which 29 members and guests were present, Prof. B. G. Elliot, Professor of Mechanical Engineering at the University of Nebraska, who spent three years in the University of Wisconsin extension department, spoke on Engineering Extension. He said that the dean of the extension department of the University of Wisconsin was an engineer, and pointed out the attitude of the people toward the university, saying that, in general, the people were prejudiced against the university and university people. In Wisconsin, however, this feeling has been removed as a result of the extension department, and the change in attitude of the people is shown by the fact that they sent letters and telegrams of protest to the legislature when the support of the extension department was about to be cut off. The advantages offered have changed the whole life of some of the students. This department has also undertaken work in the penitentiary.

VIRGINIA POLYTECHNIC INSTITUTE

The regular meeting of the Virginia Polytechnic Institute Student Branch was held on January 22. A very interesting paper on Superheaters was presented by W. R. Ellis and R. M. Hutchinson, who discussed the subject from both a mechanical and economical standpoint. During the course of the paper the practicability of superheater installation was clearly shown.

At a second meeting, held on January 29, the Branch was addressed by I. N. Moseley, who spoke on Low Water Alarms. The subject had been worked up jointly by Mr. Moseley and R. R. Connelly, and most of the up-to-date alarms were discussed in detail. Sketches were made of the various types now in use, among which were the float type, the balance type,

and the Nathan type, all of which are used on stationary boilers, and the fusible plug and sentinel types, which are used on locomotive boilers.

WORCESTER POLYTECHNIC INSTITUTE

A very interesting and successful meeting of the Student Branch of the Worcester Polytechnic Institute was held on February 4, at which 155 members and guests were present. Major L. T. Hillman of the United States Army spoke on Modern Ordnance, its Construction and Use. In his opening remarks, he spoke of the importance of the subject of "Preparedness" to engineers and brought out the fact that the engineer is a most important factor in modern warfare. The subject of ordnance was taken up under the four general topics: Small arms, cavalry and field artillery, machine guns, coast defense. Mention was made of the familiar small arms, including the rifle, granades, revolver, etc., after which a very interesting set of lantern slides was shown and explained. Several pictures presenting the principal types of field pieces were thrown upon the screen and particular mention was made of the extreme effectiveness of the rapid fire machine guns. It was explained that the fire of these forms of portable guns is confined to comparatively low elevations, while the howitzers, mortars and aeroplane guns cover the higher elevations. Of particular interest was the description of the shrapnel and ordinary bomb shells. After treating the subject of portable guns, Major Hillman spoke at some length of the coast defense ordnance, both mortars and guns, and the views of the mortar batteries and coast fortifications equipped with the larger disappearing rifles illustrated his points admirably. Photographs of the latest 14 and 16 inch rifles of the United States were shown, and mention was made of some of the difficulties and problems which arise in designing such guns and their mountings.. An interesting discussion followed Major Hillman's talk.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

49 ENGINEERING SALESMAN, in machinery department of Pennsylvania concern. Man should be not less than 35 years of age; good draftsman but primarily a salesman. Good salary for a man with these qualifications. Location Pennsylvania.

50 DRAFTSMAN, experienced in heavy machinery work and if possible chemical apparatus. Salary $25.00. Location New Jersey.

51 TOOL ROOM FOREMAN wanted by a large manufacturing company. Must be good executive and first-class mechanic. Good permanent position for the right man. In reply give full information regarding experience, age and salary wanted. Location Middle West.

53 DRAFTSMAN with some experience in structural work. Salary $100.00 a month, with good prospects of advancement. Location Ohio.

54 ASSISTANT FOREMAN for a radiator factory. Location Ohio.

55 ASSISTANT FOREMAN for gray iron foundry melting approximately 25 tons per day, particular requirement, experience with all types of moulding machines. Location Ohio.

59 COST MAN for new foundry; intelligent, up-to-date and familiar with foundry materials and equipment, and experienced in foundry costs and bookkeeping. Location Connecticut.

63 ASSISTANT PURCHASING ENGINEER for the inspection of incoming materials, for Massachusetts manufacturer of small electrical apparatus in quantities; applicants thoroughly familiar with electrical, insulating and composition casting materials; with practical knowledge of metal working and similar machinery; state details under heading, age, nationality, education, practical experience, salary, when at liberty.

64 DRAFTSMAN experienced in design of steel pulleys. Must be accurate, rapid and industrious. Salary about $25 per week. State age, experience, previous employers and references. Location Massachusetts.

66 SUPERINTENDENT for large European concern, engaged in the manufacture of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and similar articles made of rubber.

67 FOREMAN experienced in the manufacture of rubber articles for European concern as listed in position 66.

68 DEVELOPMENT WORK. Man who has had a technical and practical mechanical engineering education, with knowledge of electrical engineering, machine shop work, drafting, etc., is desired to assist in the further development of plans for constructing an improved rock tunneling machine. Location New York.

71 SALES ENGINEER for Metropolitan and New England district. Will be brought into contact with manufacturing and construction work for chemical and industrial plants. Salary depends on man.

72 FACTORY SUPERINTENDENT for large watch making concern. Location New England.

75 SALESMAN with experience in marketing high grade hot rolled electric and open hearth steel specialties; one having sufficient knowledge and information to post operations in securing proper tonnage for mill. To receive attention, state age, experience and salary expected. Name confidential.

76 PROFESSOR OF EXPERIMENTAL ENGINEERING wanted at the opening of the University in September. Essential qualifications are, first, the right sort of man; second, training and experience fitting him for the work in question. Location Pennsylvania.

77 DRAFTSMAN on detail machine design. One thoroughly familiar with this line of work. Salary $20 to $22.

78 DRAFTING AND TESTING ENGINEER. A concern doing general foundry and light machine work is desirous of securing services of a young mechanical engineer for general drafting and testing work; preferable one or two years experience in shop practice; work for the first few months will be devoted mainly to drafting out the general arrangement of the foundry, shops and apparatus. Testing to consist principally of power and heat transmission and the economical operation of mechanical devices in the shops. Give references and salary expected. Location Middle West.

83 YOUNG MECHANICAL ENGINEER, willing to start at a salary of about $25 a week, who has had experience or is interested in the operation of an isolated power plant of about 1000 b.h.p. to consist mostly of testing, estimating, superintend-

ing new construction and keeping records. Position permanent. Location Hoboken.

87 MACHINE SHOP FOREMAN, well qualified to take charge of machine department making tools and special machinery. Location New Jersey.

88 PRODUCTION ENGINEER; preferably Englishman, age 28-34, actual shop experience, machine tools, light and heavy, shop practice, for work consisting of reporting, analyzing work in shop with idea of suggestive improvements in output, etc., in munitions manufacture. Headquarters in Eastern Pennsylvania. Salary dependant upon man.

89 GENERAL SUPERINTENDENT of factory employing 150 men engaged in manufacture of small parts for universal joints for automobiles. Man capable of laying out factory, organization, production, etc. Location Indiana.

91 DRAFTSMAN experienced in the design of reinforced concrete factory buildings. In applying give age, experience, salary expected, etc. Location Waterbury, Conn.

93 MECHANICAL DRAFTSMAN, capable of laying out and designing a varied line of machinery to familiarize himself with the particular line of manufacture in view of assuming charge of drafting room of about twenty men. Must be of the best ability and capable of handling men. Location New England.

96 ASSISTANT TO MACHINE DESIGNER; young technical graduate who could take general oversight of power plant and buildings. Opportunity for advancement would be either in the designing and building of machinery or in manufacturing, for whichever line the man showed aptitude. Salary according to experience and demonstrated ability.

98 DRAFTSMAN who has had experience in the design of heavy machinery, rolling mills, etc. Location, Connecticut.

100 GREY IRON FOUNDRY FOREMAN or SUPERINTENDENT, for large modern factory located in New England and engaged in producing medium and light weight castings. Applicant must have had extensive experience in the mechanics of founding, mixture of metals and the systematic handling of men and give complete references.

101 IRON AND STEEL ENGINEER, acquainted with modern methods, to take charge of the planning of extensions and improvements of a steel works in Norway.

102 DESIGNER; an engineer, technical graduate preferred, who has had experience in the design of open feed water heaters, softeners, etc. Good position to right person. Write fully giving details of past experience and references.

104 FOREMAN of shop for manufacturing chemists. Location New Jersey.

105 CHEMIST for firm of manufacturing chemists. Location New Jersey.

107 PRODUCTION ENGINEERS; young engineers, preferably technical graduates who have had good shop experience and are familiar with the methods of progressive manufacturers. Men are desired who have had experience in machine shops, foundries, paper mills, tanneries, structural shops, or any large and highly organized industry, and who feel that they have acquired a thorough knowledge of system and modern methods, opportunities for advancement are exceptional. In reply, state age, education, experience and salary.

108 MECHANICAL DRAFTSMAN, experienced in conveying machinery, design and detail. Splendid position for right man. All communications will be treated strictly confidential, but to receive consideration should contain particulars of experience, references, age and salary expected to begin; only desire man capable of advancement as position offers good future. Location Middle West. Apply through Society.

112 ENGINEER SALESMAN wanted by firm doing business in various parts of Spanish America, with office in Chile and handling mining, agricultural, power plant and railway machinery. Must be a native of United States and graduate mechanical engineer with degree from U. S. college or university. Man not under 30 nor over 45. Ability to write specifications for pumps, steam power plant equipment and locomotives; successful experience as salesman; culture, good address and appearance essential. Unless one is assured of his especial fitness for this position, it is useless to apply. Must speak and write Spanish.

113 DRAFTSMAN with at least five years experience along mechanical lines in connection with machine design, pipe work, etc. Salary $125 per month. Location New Jersey. State record of positions held and dates.

114 YOUNG ENGINEER, capable of learning business thoroughly in shop, with view of systematizing and improving shop conditions. To right man position will eventually lead to Superintendent. Modest salary to start. Communications regarded confidentially, but should contain particulars of experience, age and salary expected to start. Middle West location.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

C-85 ENGINEER, technical graduate, ten years experience in building and power plant layout, inspection and testing, desires change in position.

C-86 ENERGETIC ENGINEER, with rolling mill and steam power plant experience on both operating and repairs, desires to locate permanently with company offering good chance for advancement.

C-87 MECHANICAL ENGINEER, age 30, married, technical graduate, seven years designing, experimental, field and production experience, desires a responsible position in the Central States.

C-88 Cornell Graduate, M.E. and M.M.E. with thirteen years experience in various forms of engineering, desires position shortly after March 1. Experienced in estimating, designing, preparing plans and specifications and in ordering materials. Has held positions of development engineer, assistant to chief engineer, superintendent of construction, etc. Eastern location preferred.

C-89 PRODUCTION ENGINEER, member experienced in the application of modern methods of management to manufacturing and sales departments.

C-90 SAFETY ENGINEER, technical graduate, age 27, wide experience in factory inspection, guarding of machinery and compensation rating. At present employed.

C-91 COMBUSTION ENGINEER, at present employed by a large industrial concern in Middle West and successfully obtaining large savings, wants to communicate with prominent concerns burning large amounts of fuel. Prefer one with headquarters in New York City.

C-92 SALES ENGINEER, MANAGER OR MANUFACTURERS' REPRESENTATIVE. Worcester Polytechnic Institute Graduate, M.E., age 36, practical experience managing sales of pumping machinery, air compressors, internal combustion engines, pressure tanks, overhead tanks and towers and design of pumping combinations. At present executive in contracting concern, but desires change.

C-93 SALES ENGINEER, married, with executive acquaintance among leading architects and contractors throughout East and Middle West. Experience in design and construction of equipment relating to elevators and street railways and at present holding responsible position with prominent New York manufacturing concern.

C-94 ENGINEER AND EXECUTIVE, mechanical engineer with extensive experience, iron foundry, machine shop, design and

operation of large power plants, central station work and as consulting engineer, is open for engagement.

C-95 Factory Engineer or Factory Planning Engineer, working out problems in mechanical handling of materials and the design, installation, maintenance and operation of machinery, including the power plant and all electrical, mechanical, compressed air and hydraulic equipment; over 20 years successful experience in machine shop of medium and heavy machinery and in handling men of the various trades; fully informed in latest manufacturing methods; 41 years of age, married, available on short notice.

C-96 Investment and Services, mechanical engineer, broad, practical experience, with capital, desires to become actively interested in established business where his experience and training will be of value; principals only.

C-97 Mechanical Engineer, at present employed as chief draftsman, desires change. Twenty years experience, general engineering, successful designer of automatic machinery, printing presses, paper handling machinery, sheet metal goods, quantity manufacture of precision parts, best of references.

C-98 Sales Engineer or Manager with technical educaion and thoroughly sound practical experience, would be pleased to communicate with a high grade manufacturer, desiring such a man.

C-99 Experimental Engineer, technical graduate, age 33, will consider either a teaching or commercial position. Four years practical experience as designer and as experimental and efficiency engineer; five years experience in teaching mechanical engineering subjects, including a large amount of experimental work; at present professor of mechanical engineering in a small university. Present salary $3000.00 per year.

C-100 Works Manager, now employed, wishes to make a change. Twenty years experience in manufacturing firearms, typewriters, automobiles, power house equipment, etc. Best of references.

C-101 Manufacturers' Representative, graduate of Massachusetts Institute of Technology, wishes to represent as sales engineer in New England, with headquarters in Boston, manufacturing concerns specializing in either mechanical or electrical materials connected with building operations. Extensive experience in the selling of building material and acquaintance with architects, engineers and contractors.

C-102 Specialist in Steam Engineering and Power Plant Equipment, conversant with practical efficiency engineering methods, will consider one or two year contract in investigating, organization or executive capacity. Ability guaranteed. Available July 1, 1916. M.E. graduate, Tau Beta Pi, Jun. Mem. Am.Soc.M.E., Assoc. Mem. A.I.E.E. Married. Experience and references upon application.

C-103 Works Engineer, or Assistant to Superintendent. Associate member, mechanical engineer, graduate M.I.T., age 29, married. Shop, design and testing experience on power plant machinery; also five years experience in investigation, design and erection of power plants, involving wide experience in power plant economy, piping, electrification of manufacturing establishments, machinery layouts and building construction. At present employed but desires to make a change in order to avoid traveling.

C-104 Advertising Manager. Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature. Replies are only desired from high grade firms wanting clean cut, dignified methods and willing to pay a suitable salary for capable services.

C-105 Executive. Technical college graduate, honor man, several years business experience, five years in present position as equipment engineer, designing tools and product, and in supervision of tool manufacturing and production jobs. Experience in drawing and swaging operations and in manufacture of field gun cases. Desires permanent position.

C-106 Export Engineer, graduate M.E., age 38, speaking seven modern languages. Fifteen years successful engineering experience. Eight years in leading positions as chief engineer and works manager of the largest machine factories, ship yards and steel works of Russia. Specialized in Germany. Familiar with the American, European and Asiatic markets, through actual visits and special study. High competence in theory and practice of modern machine manufacture, shipbuilding, and steel. Initiative business ability. Wishes connection with a reliable American firm desiring to establish an export business.

C-107 Shop Executive, A.B. Yale, M.E. Columbia, four years apprenticeship in railroad shops, seven years drafting room experience, eighteen months in charge of construction work, desires a change from present position as draftsman to one where shop experience will be of value to employer.

C-108 Executive or Purchasing Engineer, Cornell M.E., age 32, broad engineering experience; at present holding managing executive position. Good judge of human nature and able to handle men to advantage. Conversant with organization, management and efficiency problems, desires change.

C-109 Executive Engineer, graduate Stevens Institute, age 44, nine years experience in motive power departments of railways; ten years with locomotive builders, employing 2000 men, rising from mechanical engineer to vice president; desires executive or engineering position. At present employed. Experience in building and equipping new shops, extensive acquaintance among railroad officers; can furnish capital if desired.

C-110 Sales Engineer, Chief Engineer, Manager or Superintendent, experienced mechanical and civil engineer, at present employed but will be open to make new connection April 1st, 1916. Location immaterial, prefer New York or vicinity.

C-111 Sales Engineer, age 33, at present employed, with successful record as district manager in Chicago, well acquainted with architects, engineers and large manufacturing concerns, desires to handle another line in connection with present work. Experience covers refrigerating machinery, pumps, air compressors and power house equipment of various kinds.

C-112 Superintendent. Graduate Stevens Institute, age 38, married. Experience in shop and drafting room, steam and electric machinery and air compressors; designing and building electrical apparatus for naval vessels; nine years as assistant superintendent and superintendent of inspection department of two large casualty companies, desires change.

C-113 Mechanical Engineer and Purchasing Agent, M.I.T. graduate, age 29, married. Five years' experience as master mechanic in textile plants. At present employed.

C-114 Assistant Mechanical Engineer, Cornell M.E. graduate; age 25; considerable drafting room experience and at present employed as assistant mechanical engineer with a large coal mining company, desires to make a change. For the last two years experience chiefly confined to power plants and testing power plant equipment. Location, New York preferred.

C-115 Opportunity for advancement with manufacturing concern, large central station power company or consulting engineer, wanted by member; age 35, technical training in mechanical, electrical and building construction course at Lowell Institute, experience in drafting room and design of steam boilers and steel plant work in Massachusetts. Boston location preferred.

C-116 Student Member, Bucknell University, free to go anywhere giving chance for advancement, prefers mathematical work, record good, references when needed. Will graduate in June.

C-117 Assistant to Executive Officer: technical graduate, M.E., having had experience in sales, cost and executive work; at present employed; desires better opportunity for advancement. New York or vicinity preferred.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE AM. SOC. M. E.

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

ENGINEERING AS A CAREER. A series of papers by eminent engineers. Edited by F. H. Newell and C. E. Drayer. *New York, D. Van Nostrand Co., 1916.* Gift of Publishers. Price, $1.00.

This series of essays is designed to give information to young men on the prospect of success in adopting the engineering profession for their life work. It includes short essays on Mechanical, Railway, Hydraulic, Metallurgical, Electrical Chemical, Marine, Sanitary, Municipal and Bridge Engineering. They are written by men who have gained success in these branches; and in many instances interesting personal reminiscences are given. The book should be of especial value to professional advisers of youth, and to parents who have the opportunity to learn the aptitude of their sons. W. P. C.

HANDBOOK OF CARBURETION, Arthur B. Browne. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price $2.00.

A comprehensive treatment of the fundamental principles governing the carburetion of air. It includes the methods of testing carburetors, and has a chapter on the Chemistry of Carburetion. W. P. C.

INDUSTRIAL USES OF FUEL OIL, F. B. Dunn. *San Francisco, Technical Publishing Co., 1916.* Gift of Journal of Electricity, Power & Gas. Price $3.00.

This is a practical book for practical men, covering matter not included in any other book. It covers stationary, locomotive and marine oil fired boilers and the use as fuel in the clay, lime, cement, glass sugar and rubber industries, in metallurgical and shop furnaces, in the steel industry, and the domestic use. The treatment is very complete. W. P. C.

MECHANICAL ENGINEERS' POCKET BOOK, William Kent. ed. 9. *New York, John Wiley & Sons, 1916.* Gift of Publisher. Price $5.00.

It is six years since the previous edition was published, and the changes and advances in engineering practice have made necessary great revision. The book is indispensable. W. P. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Yearbook 1916. Gift.

AMERICAN SOCIETY OF SWEDISH ENGINEERS. List of Members, 1916. Brooklyn, 1916. Gift of Society.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS. Proceedings vol. 7, 1914. *Chicago, 1914.* Gift of Association.

BOSTON. TRANSIT COMMISSION. 21st Annual Report. *Boston, 1915.* Gift of Boston Transit Commission.

CARNEGIE INSTITUTION OF WASHINGTON. Year Book No. 14, 1915. *Washington, 1915.* Gift of Carnegie Institution.

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GIFT OF AERONAUTICAL SOCIETY

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the February 1916 issue of The Journal.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of their Appearance in the Survey.

THE solution of one engineering problem usually leads to the creation of another one, which in its turn is solved sooner or later by the ingenuity of "mechanical men," as engineers are still sometimes called by laymen. A good case in this connection is that of the balancing of rotating masses. The high speed electric generator and motor, the steam turbine, turbo-blower, centrifugal pump, etc., have made the question of proper balancing of rotating machine parts far more important than it has ever been before, and its proper solution leads sometimes to results of considerable importance. In the present issue an abstract of an article on the proper balancing of rotating machine parts is given, describing among other things the Lavaczeck system of balancing, which is claimed to permit of obtaining a theoretically perfect balancing and appears to be of great sensitiveness.

THIS MONTH'S ABSTRACTS

In the section Aeronautics, are described aeroplane engines built in Italy. In this connection attention is called to an article in *Flight* (Vol. 8, No. 2, page 40, Jan. 13, 1916, and following) describing a 160 h.p. Mercedes engine found on a captured German aeroplane. The question of the material employed in the construction of the engine has not yet been fully established, but as to the design, several figures are shown illustrating the engine. The bottom half of the Mercedes base chamber is shown as seen from above. Centrally at top is seen the air intake to the carbureter which leads from two apertures in the wall of the casing to the other side. Very long steel bolts support the bearings. A detailed sketch of the partition walls housing the half bearings of the crank shaft in the top half of the base chamber is likewise shown. In the connecting rod of the engine the perforated floating sleeve rides between the small end and the gudgeon pin. On the whole it appears that the parts are of quite robust proportions and generous weight, and it is by careful and scientific disposition of the metal that the remarkable result obtained has been made possible in the case of the crank chamber. The shell itself is extremely thin, but is made very rigid by the manner in which it is braced. In the lower half there is a double bottom running nearly the whole length of the space enclosed by forming the oil sump. A series of exterior longitudinal fins below the casing not only give stiffness but also serve as radiators for cooling the oil. By the way, another duplication of duties is seen in the manner in which the air to the carbureter is also made to cool the oil and in doing so to become itself warmed as an aid to good carburetion. To this end the sump does not occupy the full length of the casing but really forms two compartments in the double bottom, one in front and one in the rear, connected together by a large diameter tube. Around this tube and between the adjacent end walls of the two compartments all the air to the carbureter has to pass, there being apertures cut in the side of the crank case that lead to the carbureter situated on the other side of the engine. This is an arrangement, however, the advisability of which is doubtful. The transverse end passages form a ready receptacle for the accumulation of gasoline drippings and also for oil leaks. Should a back fire occur in the carbureter, the vapor in the passage is liable to become ignited and to set fire to the oil and not unlikely to the machine itself.

Of further interest to aeronautical engineers may be a somewhat general article in *L'Aerophile* (Vol. 23, No. 23-24, page 266, Dec. 1-15, 1915) on the various shapes of floats for seaplanes. The article brings out the important fact that while an ordinary boat with its single floating element has to maintain stability in all the three respects, that is, longitudinal, lateral, and of motion, the avion is in itself, from a static point of view, extremely stable laterally. It has also a good stability of motion, while the longitudinal stability is maintained by the little tail float as well as by the volume of the main float being ahead of the center of gravity. In addition to that, as soon as the aeroplane has acquired a certain amount of velocity, the longitudinal stability of the air part of the machine stabilizes the entire system. Hence, the question of stability becomes really secondary from the point of view of design of the machine.

In the same section is briefly abstracted a paper on the aeroplane, being a general discussion of the aeroplane with special regard to mechanics of flight and stabilization.

The transport of material in the form of dust, with particular application to handling arsenical soot, is discussed in an article abstracted from the Journal of the Society of Chemical Industry.

In the section Engineering Materials is an interesting discussion of the subject of semi-steel, taken from a paper read

before the Lancashire Branch of the British Foundrymen's Association. The paper discusses various troubles in the production of semi-steel and methods of obviating them. Judging by the data of the paper, semi-steel does not possess much promise of further development.

The paper on crystal twinning by direct strain presents data of an investigation of apparently a very difficult subject.

The Tessé rotary cylinder motor is described in the section Internal Combustion Engines. Its essential feature is the method of locating the connecting rods and conecting them to the disc.

A discussion of the subject of aluminum alloy piston, with special reference to the Cothias type, is given from a paper before the Society of Automobile Engineers.

The same Society, by the way, in the January, 1916, issue of the *Bulletin*, publishes a report of its Metropolitan Section Research Committee on automobile engine governors, mainly with reference to their use on motor trucks. The various classes of types of governors for the internal combustion engine are tentatively listed as follows:

1—Hit-or-miss, inlet valve closed or exhaust open, so causing engine to miss one or more power strokes.
2—Inlet valve control, time of opening or closing inlet valve varied.
3—Ignition control, ignition spark omitted.
4—Quality of fuel, lean or recharged.
5—Quantity of fuel, throttling charge.

The only type for consideration in automobile practice is said to be the quantity of fuel type which controls the fuel supply after the fashion of the steam engines that throttle the steam on its way to the engine. In the automobile, the throttling is usually accomplished by a damper or other balance valve placed in the intake pipe. The governor operation may depend on the speed of either the engine or the vehicle. In the engine speed type, the maximum speed of the engine is fixed and its racing prevented. In the vehicle speed type, the full horse power output of the engine can be obtained for low gear work when it is desirable or expedient that the engine be forced to do its utmost. In one device on the market these two control methods have been combined.

The report describes four classes of governors, Centrifugal, Hydraulic, Inherent Design, and Gas Velocity in Intake. Some data on governor drive and other details are presented.

In the section Machine Shop will be found an abstract of an article giving a formula for the cutting speed of twist drills, derived from experimental work on other cutting tools. In the article itself an alinement chart is also given to express the relations of the formula.

In the same section is given an abstract of an article by P. W. Abbott representing a study in the various elements entering into the production of good threads, external and internal. Among other things the writer insists that the choice of lubricant is of secondary value and the importance often attached to it is due to the use of taps and dies which do not cut but push or force the metal off and out of their way. If the tools are actually cutting, all that is needed is something to keep the work and tools cool.

In the section on Mechanics are described experiments made to determine the distribution of vertical pressure transmitted through sand. In another abstract is discussed the problem of balancing of machine parts referred to briefly above. Another paper, this time in Lumière Electrique, on the same subject, has been received too late for publishing an abstract of it in this issue.

The subject of boiler corrosion is discussed in two papers. That by John C. B. Kershaw takes up the subject generally, with special reference to methods of accumulation of dissolved salts in feed water. The other article, by M. R. Schulz, takes the subject up from the point of view of utilization of water of condensation from steam turbines for boiler feeding and conditions under which oil and impurities may be present in boilers fed in this way. A point which both writers emphasize is that water which could be safely used for boilers operating at pressures and temperatures in general use some 10 or 15 years ago may become corrosive in their action at the high steam pressures and temperatures now in use. Equations for ammonia based on new experimental material are presented by Fred G. Keyes.

Attention is called to a list of charts at the end of the Engineering Survey. The use of charts for facilitating various calculations is rapidly increasing and an endeavor will be made to list such as are of interest to mechanical engineers.

Aeronautics

Aeroplane Engines in Italy, W. F. Bradley

Data on the progress of construction of aeroplane engines in Italy, and some data on the development of automobile machinery.

An interesting tendency is shown by the change from the pump to the thermosyphon method of cooling. It is admitted that it is a difficult task to produce a thermosyphon cooled motor which will be satisfactory both on the hot plains of Italy and in the Alpine passes, but it is claimed that with careful design and such good foundry work as they can produce in Italy, the pump can be abolished.

At the Chiribirri factory the writer was shown a 40 h.p. aviation motor with aluminum cylinders and cast iron liners built in 1912 and flown in that year. The paper shows also a fixed six cylinder aviation motor built by the same concern. Fiat is at presented interested in the six cylinder vertical water cooled type with inclined overhead valves and a single overhead cam shaft. The cylinders are of steel, separate, with a sheet steel water jacket common to the cylinders in pairs. Lancia is building twin sixes with horizontal valves. The Diatto Co. has taken up the Bugatti aviation motor which has six separate steel cylinders welded together and surrounded by a copper water jacket. There are four vertical valves per cylinder with a patented mechanism by which a single cam operates direct on a pair of valves. As in France, it is expected that the aviation motor will tend to bring the twin six motor into greater prominence and assist in its adoption for car work. (Italy Developing Aeroplane Engines, *The Automobile*, vol. 34, no. 4, p. 182, January 27, 1916, 3 pp., 3 figs. *d.*)

The Aeroplane, L. Goldmerstein

A general discussion of the aeroplane with special regard to mechanics of flight and stabilization.

The author pays particular attention to disturbances in stability due to air gusts and variation in the direction and strength of the wind. All of the stabilizing systems are based on the principle that when a machine gets out of equilibrium, some of its component parts such as ailerons, fins or tiller, will in some way be moved to such an angle as to cause the machine to return to its original position. The operation of all stabilizers is based on the assumption that the machine is fly-

ing or moving through the air at a certain speed. But when Wilbur Wright went up in the air about 300 ft., stopped his engine and then tried to operate it, he found that with the engine still the controls were absolutely useless, so that (as his brother expressed it) he "fell down 200 ft. in a time too short to be comfortable." All stabilizing devices are effective only when the machine maintains a certain speed.

Another point which the author takes up is the relation between stability and transient stresses on the machine. The aeroplane is subjected all the time to puffs of the wind and as the gusts are applied for extremely short periods there will be a blow on the plane practically every time the wind changes. That is one of the reasons why monoplanes have been practically discarded, as their wings are apt to collapse. For example the German Taube which is a modified Ettrich monoplane has been almost entirely discarded and biplanes substituted for it. The Taube was wonderfully stable and its stability was its undoing, for instead of giving way under gusts of wind, it opposed them, and such excessive transient stresses were produced that the machine collapsed. (*S. A. E. Bulletin*, vol. 9, no. 3, p. 166, December 1915, 12 pp., 4 figs., *t.*)

Conveying

THE TRANSPORT OF MATERIAL IN THE FORM OF DUST, T. C. Cloud

Discussion of the removal and transport of very fine material, such as, for example, dust from the flues of a set of Lancashire Boilers, or of impalpable powders produced in large quantities.

In a case with which the author had to deal, furnaces were producing a gas highly charged with arsenious oxide. This was to a large extent deposited in a complicated system of condensing chambers and flues followed by filtration through bags in a bag house. The points at which it was necessary to remove the arsenious oxide from the bag house flues, etc., were numerous, and it was also necessary to deliver all the material to the packing room where it could be packed in casks for marketing. After some experimentation a vacuum plant, of which the following is a description, was designed:

The vacuum pump at normal speed of 160 r.p.m. has a displacement of 20,000 cu. ft. per hr. and will produce a vacuum of 18 in. of mercury if all valves to the various branch mains are closed. In the packing house the pipe main enters a cyclone separator in which the bulk of the arsenious oxide is deposited. Following this is another small separator. Finally the air is drawn through a shallow layer of water and then passes to the vacuum pump. The cyclone separator has a small storage capacity, and the arsenical soot is automatically removed from this apparatus and discharged into the casks placed below. The smaller separator is furnished with baffle plates and a collecting receptacle from which the deposit is only discharged at long intervals when the vacuum is off. The water separator is arranged so that a small continuous supply of water can be passed through it, or it may be charged and discharged intermittently.

In the piping about the works all bends and entering branches are of large radius, and for moving the material upwards all vertical members are avoided and inclined pipes substituted. At numerous points capped branches are arranged, to which, on the removal of the cap, suitable flexible hose, either metallic or reinforced rubber, can be attached. A suitable nozzle is fixed on the end of the hose, and on inserting this into the accumulated deposit the latter is immediately sucked up and conveyed to the separating plant.

This plant having an air pump capacity of 20,000 cu. ft. per hr. deals with 1½ to 2 tons of collected arsenious oxide per hr., and the farthest point at which a branch is situated is about 200 yd. from the separator. The pump in this instance is electrically driven, working at the rate of 12 to 14 h.p. It has been found that all annoyance caused by the handling of this material is removed and respirators are superfluous. (*Journal of the Society of Chemical Industry*, vol. 35, no. 1, p. 7, January 15, 1916, 2 pp. *d.*)

Engineering Materials

SEMI-STEEL, J. E. Hurst

The article represents a paper read before the Lancashire Branch of the British Foundrymen's Association. It appears that the most important difficulty in the production of semi-steel is that of maintaining a uniform content of carbon in the melting. At first sight the mechanism of the melting of steel in the cupola is apparently simple. Steel heated in contact with carbon or coke especially in an atmosphere containing carbon monoxide absorbs carbon as the carbon content of the steel increases or the melting point of the steel decreases, until finally the melting point of the steel in the cupola is gradually reduced to a figure within the temperature range of the cupola.

There are, however, several points which complicate this simple looking process. In the first place the effect of temperature on the absorption of carbon is very often misunderstood. It must be remembered that the higher the temperature the more rapid the absorption of carbon by steel. Moreover this absorption of carbon is not an instantaneous action but requires a certain amount of time, the length of time required being in its turn largely dependent on the temperature which establishes the relation between time and temperature. From a practical point of view it is important to bear in mind that the cupola method of melting offers no practical means of controlling such variables as time and temperature, with the result that the chemical composition and particularly the carbon content, on which the whole of the properties largely depend, cannot be uniform.

In a blow the first charge comes in contact with the hot coke long before the subsequent charges, hence as far as the carbon content is concerned it is not necessarily of the same composition. Further, the character of the steel scrap, the manner in which it is charged and in which it sinks down in the sack, all tend to influence the carbon content in various ways. Even after the steel has passed the melting zone, the absorption of carbon is not finished, for the metal drops down amongst the bed coke and there continues to absorb carbon.

The following experiment has been made in this connection. A charge consisting of hematite and cold blast pig, together with 20 per cent of steel scrap in the form of turnings and borings was charged into the furnace, and the blast turned on. Five minutes afterwards a small clay laboratory crucible was introduced into the cupola at the end of a steel rod inserted through a tuyere hole. The drops of molten metal caught by the crucible were withdrawn and a further sample taken. The analysis of the two samples together with that of the final metal are given in Table 1. The two samples taken were quenched in water, with the result that the carbon was all in the combined form. The steel borings portion of the charge was put in first and consisted of steel of about 0.25 per cent C.

The difficulty of obtaining perfectly homogeneous cast iron has led to the introduction of mixtures of pig iron and known percentages of steel, which are recommended for the production of castings. This method has been largely used in Germany and finds a parallel in the British manufacture of pig

plate, but even with the method it should be remembered that any mixture of cast iron, the carbon content of which is not the eutectic percentage for the given composition, will, on being melted in contact with carbon as in the cupola, absorb carbon to a greater or lesser extent according to the particular conditions of the cupola. The only remedy for this defect of semi-steel is to adopt some plan similar to the mixer in steel manufacture, or better still to melt in furnaces so designed that the metal is not in contact with carbon.

The author points out the essential difference between semi-steel made by the addition of steel in the cupola and that made by the addition of steel to molten iron in the ladle. However, even in semi-steel of the latter type it is necessary that the metal be well stirred.

Regarding the casting of semi-steel mixtures there seems to exist a large amount of uncertainty and contradiction, some of which may be due among other causes to the influence of the casting temperature. As far as the writer's experience goes, semi-steel can be cast exactly as any other cast iron with the same chemical composition, but stirring is practically the only way of insuring homogeneity of semi-steel mixtures. Small minute pin holes are a serious trouble which occurs

TABLE 1 ANALYSIS OF TWO SAMPLES OF SEMI-STEEL

	Sample 1	Sample 2	Final Metal
	Per cent	Per cent	Per cent
CC	2.50	2.94	0.86
Gr	....	....	3.07
Total C	....	....	3.93
Si	1.21	1.59	1.63
Mn	not estimated	not estimated	0.48
S	not estimated	not estimated	0.085
P	0.73	0.74	0.66

very frequently in semi-steel; the author has personally experienced this trouble, especially in high percentage steel mixtures (30 per cent and 40 per cent), and furthermore the trouble was accentuated in those castings in the mixture of which solid steel scrap was used. The author is of the opinion that the Fe_2O_3 oxide cannot exist in the cast iron in the presence of high silicon, and that pin holes are caused not so much by direct oxidation as by excessive gas absorption and local defects. The use of ferro-manganese as a deoxidizer is unnecessary, but aluminum in small quantities is undoubtedly beneficial.

Hard spots constitute another serious trouble in connection with semi-steel, but they are also common in castings without steel, especially low silicon iron. The mechanical strength of semi-steel is claimed to be from 20 to 30 per cent above that of ordinary cast iron; tests made by the author do not, however, show very high increase in tensile strength.

In all the author comes to the conclusion that the mechanical properties of semi-steel vary, and that the steel itself may conditionally be partly responsible for this change in the mechanical strength; but the conditions are of such a complex and uncontrollable nature, that cupola melted semi-steel must be considered a failure when considered from the standpoint of those who urge the wonderful results of this product. However, semi-steel possesses excellent wearing properties. What the author believes is that the only effect of steel in the mixtures is to reduce the silicon and phosphorous, thus making a cheap substitute for the somewhat costly hematite and cold blast irons. The true object of semi-steel mixtures is undoubtedly attained in the mixtures of steel and cast iron made in the ladle, the practical objection to this method being that the temperature of the metal is greatly lowered, and therefore high percentage steel mixtures are not possible by this method. Two methods are suggested to overcome this difficulty. One is to melt the cast iron in a reverbatory or a regenerative furnace, and then add the steel scrap to the molten cast iron. The other method recommends placing the steel scrap, preferably in the form of punchings or turnings previously heated to a red heat, in the bottom of the ladle. Into this ladle is tapped the heated cast iron from the cupola and in the metal is immersed a can of thermit. The reaction which ensues provides sufficient heat to rapidly melt the steel scrap and maintain the temperature of the whole metal. None of these methods, however, possess the peculiar advantages of the cupola method of melting, which are cheapness, economy, speed, and adaptability. (Lancashire Branch of the British Foundrymen's Association, through *The Foundry Trade Journal*, vol. 17, no. 168, p. 657, December 1915, 5 pp., 3 figs. *ep.*)

CRYSTAL TWINNING BY DIRECT STRAIN, C. A. Edwards

Data of an investigation made to determine whether structural changes in metals can be produced without subjecting the mass to an annealing operation. The conclusion is drawn

FIG. 1 MULTIPLE TWINNING IN TIN SHOWING CHANGE OF DIRECTION IN CERTAIN TWINS PASSING THROUGH OTHERS —UNETCHED AND MAGNIFIED 150 DIAMETERS

that acicular markings, or markings having sharp points like needles, formed on tin and zinc are actually twin crystals and not mere surface appearances.

The difficulty of the investigation lay in the fact that the lightest rubbing on the finest emery has the effect of completely changing the structure of tin and zinc for a considerable depth below the surface. If, however, the upper layer of broken up crystals or amorphous material is dissolved off by immersing the specimen in strong acid, and the surface again polished on chamois leather, the structure can then be developed by ordinary etching. By working in this way it was possible to obtain the evidence required to demonstrate that twin crystals are produced when tin and zinc are strained.

Microphotographs taken in the course of the investigation show the abrupt change in direction of the so-called slip bands as they pass through the markings under discussion, and are further proof that the latter are twin crystals. Fig. 1 is still more significant, because it shows a similar change in direction of certain twin crystals as they pass through twins which cannot be explained in any other way.

Regarding the mechanism of the formation of twin crystals

in metals by direct mechanical change, the author attributes the increased hardness of the metal to the increased kinetic energy at the disturbed surfaces, and asks whether crystal twinning involves external movement of a kind which will produce the amorphous layers. He believes that rotation, which occurs in twinning as affected by the fact that the twinning planes are not perfectly smooth but consist of numerous rectangular projections, must cause a crushing or breaking up of the crystalline material on those surfaces.

The facts which have been observed in connection with the twinning of zinc and tin indicate that the rotation does not proceed *en masse* in a simple manner. The units which go to form twin lamellae cannot retain after twinning the same relative position to each other as they did before the twinning rotation took place in the individual units or small groups of such units; and since a movement of this kind must cause a further grinding between the units or groups of units inside the twin lamellae, the amount of amorphous matter or distortion of the space-lattice produced during mechanical crystal twinning must be a maximum. (*British Institute of Metals*, through *The Iron Trade Review*, vol. 58, no. 6, p. 341, Feb. 10, 1916, 5 pp., 13 figs.)

Internal Combustion Engines

Tessé Rotary Cylinder Motor

In radial rotary cylinder motors the coupling of the connecting-rods of the pistons is usually defective because only the foot of the principal or primary connecting-rod describes a circle. The feet of the other connecting-rods being pivoted or jointed on journals or trunnions in rigid connection with the first, describe dissimilar curves and with a non-uniform movement. This causes detrimental inertia stresses due to variations of velocity of the feet of the secondary connecting-rods. The obliquity of the secondary connecting-rods being much greater than that of the principal connecting-rod, the reactions of the pistons on their cylinders are greater. The functions of the various cylinders do not occur during the same angular periods. Also as the principal connecting-rod is reinforced a balance of the system of connecting-rods coupled to the crank is not possible. In the case of connecting-rods coupled to the crank by means of curved slippers or ends, the large number of conecting-rods usually employed in motors of this kind renders it compulsory to reduce the width of the slipper of each connecting-rod foot to such dimensions that the least defect of adjustment or lubrication causes heavy wear or even gripping of the shoes.

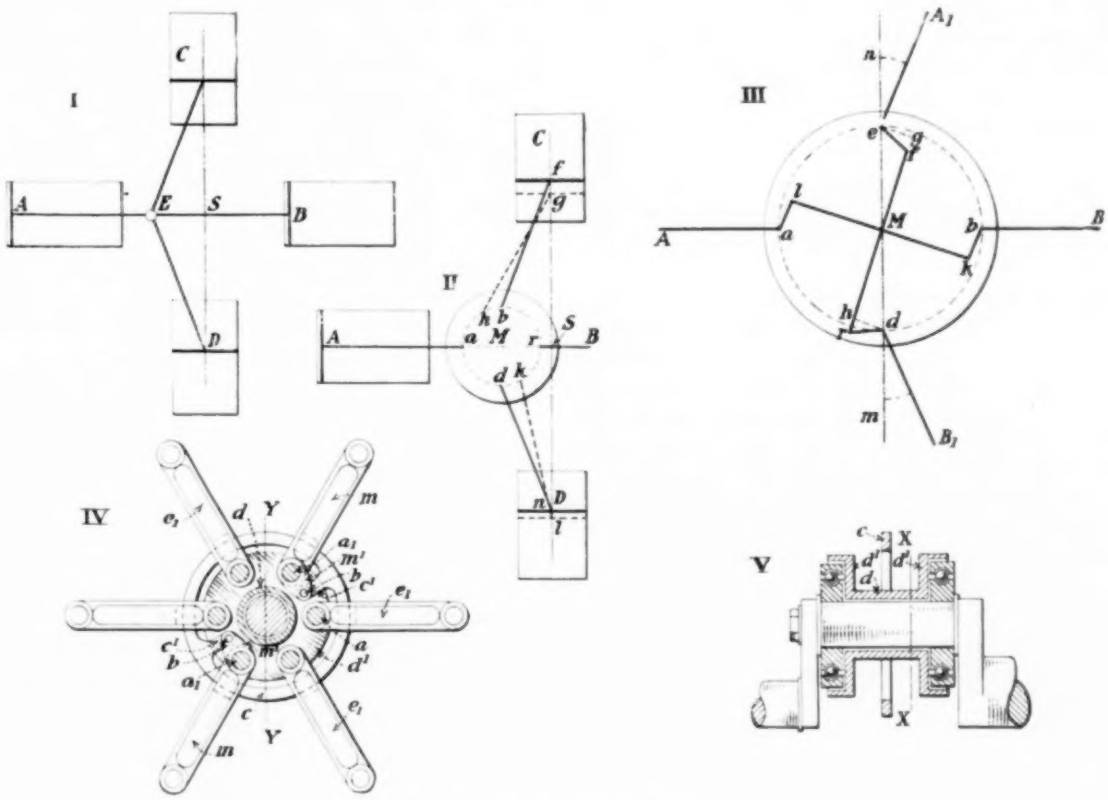


Fig. 2 Tessé Rotary Motor

Fig. 2, I shows an engine of the Tessé system with four cylinders rotating about the fixed centre S, the ends of the connecting-rods being attached to the fixed crank E. Because of the eccentric position of E with respect to the circle of rotation of the cylinders, the pistons A, B, C, D will move in their cylinders exactly as they would supposing the cylinders fixed and E rotating as a movable crank around S. For uniform motion the pistons would execute in the cylinders simple harmonic vibrations varied slightly by the obliquity of the connecting-rods.

With a large number of cylinders it is inconvenient to connect all the rods to the single crank-pin E, but if the crank-pins are distributed around a disc as shown in Fig. II the fixing is much simpler and the motion of the pistons much the same as before, provided that the disc rotates about its own centre M at the same rate and in the same direction as the cylinders. If the disc, however, is simply free to rotate about its fixed centre M, then the connecting-rods and pistons are not completely constrained; that is, for any given position of cylinder C the connecting-rod may be in any posi-

tion, $b\,f$ or $g\,h$ (Fig. II), the corresponding positions of the connecting-rods of cylinder D being $d\,n$ or $k\,l$.

It is necessary, therefore, to arrange links connecting the cylinders with the disc so that the latter is driven around at a uniform rate with the rotating cylinders. In the Tessé rotary cylinder motor this is achieved by making bell-crank levers of two connecting-rods driving the disc. These are shown as $B\,b\,k$ and $A\,a\,l$ (Fig. III) hinged to the disc at the points b and a on opposite ends of a diameter of the disc. The ends $k\,l$ of these bell-crank levers are connected by a coupler $l\,k$. The positions of the connecting-rods and coupler after the cylinders have turned through an angle of 90 deg. are shown at $A_1\,e\,f$ and $B_1\,d\,r$ respectively. In this position it will be seen that the connecting-rod $B_1\,d$ is no longer collinear with a diameter of the disc, but has turned through an angle $B_1\,d\,m$ relatively to it. The arm $r\,d$ has also turned through an equal angle $h\,d\,r$ relatively to the disc, and this angle is practically equal to the angle $g\,e\,f$ through which the coupler has pulled the arm $e\,f$ of the other connecting-rod $A_1\,e$. It is plain, then, that the angle $A_1\,e\,n$ through which the connecting-rod $A_1\,e$ has turned relatively to the disc is equal practically to the angle $B_1\,d\,m$.

Fig. IV, is a section of the connecting-rod system on X-X Fig. V, and Fig. V is a section on Y-Y, Fig. IV, with the connecting-rods omitted; $m\,m^1$, $m\,m^1$ represent the principal or master connecting-rods, which are formed as bell-crank levers, and $e_1\,e_1\,e_1$ represent secondary connecting-rods for the other cylinders. In the example shown two principal connecting-rods are employed to drive the disc d^1, but any even number may be employed. All the connecting-rods, principal and secondary, are analogously jointed or pivoted at $a_1\,a_1\,a_1$ on a central hub member d, which is itself mounted through the medium of ball bearings on the crank-pin. The pivot pins a are mounted in and lie between the inside faces d^1 of the crank hub d and the pivoted ends of the connecting-rods e and $m\,m^1$ are forked, the limbs passing on each side of the ring or connecting member c and being pivoted on the pins a. The two principal connecting-rods are mechanically connected together by a ring c (the coupler), to which their short arms $m^1\,m^1$ are pivotally attached by pins or trunnions $b\,b$ passed through these forked short arms, and through inwardly projecting arms $c^1\,c^1$ of the ring c, but not into the faces d^1 of the crank hub. (*The Practical Engineer,* vol. 53, no. 1506, p. 4, Jan. 6, 1916, 2 pp., 5 figs. *d.*)

THE ALUMINUM ALLOY PISTON, James E. Diamond

The author discusses the problem of the aluminum alloy piston and considers certain phases of piston design.

The coefficient of friction of an aluminum alloy suitable for pistons is about 50 per cent of that of cast iron. Because of the greater heat conductivity of the aluminum alloy piston, under favorable lubricating conditions very little, if any, carbon is deposited. In case an aluminum piston seizes it is damaged only in rare cases and the cylinder is practically never injured.

Permanent mold pistons are considered superior to sand cast, being 25 per cent harder and having a tensile strength ranging between 25,000 and 30,000 lb. per sq. in. Further, they can be ground quite well with kerosene which is a suitable grinding medium.

The design of aluminum alloy pistons can follow closely that of iron pistons but it is advisable to rib the head to better carry heat away from it, eliminating the possibility of a gradual deterioration of the metal through being subjected to a high temperature for a long time. Wherever possible, it is wise to increase the length of the piston, possibly as much as 25 per cent.

The author believes that the prejudice against the "hour glass" type of piston is gradually disappearing, and it was mainly this that stood in the way of commercial introduction of the Cothias process of piston manufacture. (*S. A. E. Bulletin,* vol. 9, no. 3, p. 177, December 1915, 5 pp. *p.*)

Machine Shop

EFFECT OF FEED AND DIAMETER ON CUTTING SPEED OF DRILLS, A. Lewis Jenkins

The article gives a formula for the cutting speed of twist drills derived from experimental work on other cutting tools. This formula gives the speed of cutting in terms of the drill diameter and feed, in addition to which a certain constant is used. An alinement chart is also given to express the relations of the formula.

The cutting speed is a function of two variables, the feed and the diameter. When the feed is constant the cutting speed, increases, according to the formula of Taylor, with the diameter. It has been generally observed that for a given drill working in a material the cutting speed may be increased when the feed is decreased, and vice versa. The feed is directly proportional to the thickness of the chip as already shown by Taylor.

The author from data furnished by the experiments of Taylor, Nicholson, Lindner, Herbert and others, expresses the relation between feed and cutting speed for drills working on cast iron, steel and brass, with a fair degree of accuracy by the equation

$$V = \frac{constant}{t^{0.24}} \qquad [1]$$

where t is the feed in inches per revolution, and it was further found that the relation used when the cutting speed is constant for all diameters is represented by the formula

$$t = \frac{d^{1/3}}{K} \qquad [2]$$

where K is a constant depending upon the material drilled, the shape and construction of the drill, and whether it is made of high-speed or carbon steel. The author gives the following table of values of factor K in the above formula:

Kind of Drill	Cast Iron	Hard Steel	Medium Steel	Soft Steel	Brass
High-speed	80	115	125	140	105
Carbon	64	92	100	112	84

The following equation is obtained by combining equation [1] with another equation derived from the Taylor equation for the cutting speed of a drill

$$V = constant \times \frac{d^{0.08}}{t^{0.24}}$$

from which the revolutions per minute are expressed by the equation

$$N = \frac{C}{d^{0.92}t^{0.24}}$$

where C is a constant depending on the work, the drill and the feed.

A chart is given for graphically solving this equation. This chart also shows the feed in inches per minute when the revolutions per minute and feed in inches per revolution are known. The author remarks, however, that for a given class of work it is necessary to do more or less experimenting in order to find the best feeds and speeds to use and after these have been determined, it is not always possible to get them from the machine. (*American Machinist,* vol. 44, no. 4, p. 152, January 27, 1916, 3 pp., 1 fig., ep.)

On Methods of Threading, P. W. Abbott

The article presents a study in the various elements entering into the production of good threads internal and external.

The author insists that just as accurate work can be done in machining threads as on plain cylindrical work, at no greater cost than poorly cut threads and without the necessity of any hand work. The taps and dies must, however, be correct and the author does not believe that accurate work can be done with the commercial taps and dies sold by the tap and die manufacturers at the present time.

He recommends the following specification: The threads in dies shall be burnished smooth after hardening to remove the hardening scale and to correct the lead. After this the dies shall be ground on outside diameter and on both sides true with pitch diameter. That means that they shall be ground from the thread itself. The die should be 0.005 in. over-size on pitch diameter and should cut a thread whose lead will not vary over 0.002 in. either way, in 1 in. Taps should be straightened after hardening to be within 0.002 in. on the pitch diameter and to show correct for lead within 0.002 in. either way, in 1 in.

The author recommends the use on threaded or tapped work of roughing and finishing cuts when necessary. Accurate threads cannot be tapped in one cut either by hand or machine, but they can be tapped with the use of roughing and finishing taps, the roughing tap being 0.010 in. smaller than the finishing tap. On large work of say 12 pitch, two dies should be used, a rougher and a finisher.

The choice of lubricant is of secondary value and the importance often attached to it is due to the use of taps and dies which do not cut but push or force the metal off and out of their way. If the tools are actually cutting, all that is needed is something to keep the work and tools cool, and the correct method is to direct oil under pressure through the threading spindle and out of the front or cutting side of the die, preventing chips from getting into the die and holder to clog and damage the die and threads.

As to lead, the author believes that the only thing that affects lead is the tools doing the thread cutting and to know what kind of lead one gets, means must be provided for measuring it. The saw-tooth gages will show whether the lead is good or bad, but not *how* good or *how* bad. Hence there should be in every department cutting external threads, a lead-testing fixture (usually reading the lead in thousandths).

Threading on multiple spindle automatics should not be done at an excessive speed, and it is very necessary that the proper size of tap drill or boring be used for each size of hole to be tapped.

The quality of stock materially affects results since if it varies in hardness the threads will vary also, due to the spring of the dies. Therefore stock should be purchased to exact analysis and Brinell hardness within reasonable limits for both the bar stock and forgings.

The author discusses also the desirable limits of actual work and the alinement of tools. (*What's the Matter with Our Methods of Threading?* P. W. Abbott, *American Machinist*, vol. 44, no. 4, p. 173, January 27, 1916, 3 pp. *p*).

Mechanics

Experiments on Distribution of Vertical Pressure through Sand, Prof. Melvin E. Enger

Description of experiments made to determine the distribution of vertical pressure transmitted through sand. These experiments were carried on at the University of Illinois, and thesis work by several students and more elaborate experiments along the same lines have been planned at the same University by the Joint Committee on Stresses in Railroad Tracks.

Experiments were made with depths of sand of 6, 12 and 18 in., the sand being thoroughly compacted before taking readings. In order to determine the effect of the size of the area loaded upon the way the pressure is transmitted through the sand, the load was applied to plates 9 in., 13½ in. and 21 in. in diameter, and measured with a 6 in. diaphragm of packing rubber. In these experiments the center of the diaphragm was directly below the center of the plate to which the load was applied, and as shown by Fig. 3A, the size of the loaded area has an important effect upon the proportion of the ap-

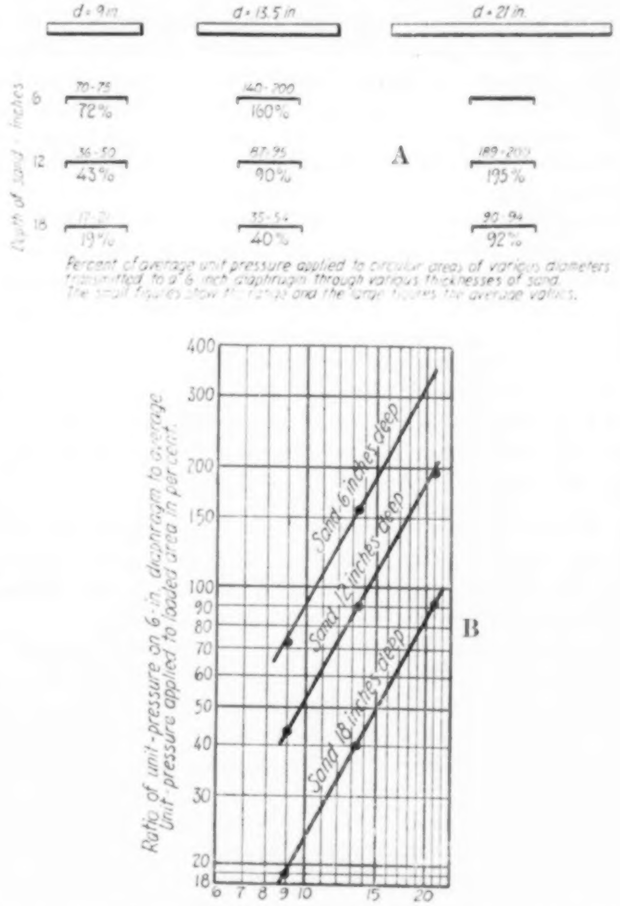


Fig. 3 Distribution of Vertical Pressure Through Sand

A, Results of Tests Concerning Effect of Size of the Area Loaded upon the Way the Pressure is Transmitted through the Sand; B, Curves Showing Relation between Diameter of Loaded Area and Load Transmitted to 6-in. Diaphragm

plied average unit pressure transmitted through sand of a given depth to the diaphragm. In these tests the 21 in. plate carried loads up to 18000 lb., the 13.5 in. plate up to 9000 lb. and the 9 in. plate up to 2500 lb.

Fig. B gives curves showing the relation between diameter of loaded area and load transmitted to 6 in. diaphragm. In it parallel straight lines pass through the points plotted for each given depth of sand. From the slope of the lines it is found that the proportion of the applied average unit load which is transmitted through sand of a given depth to a diaphragm directly below varies as the 1.86 power of the diameter of the loaded area.

In the experimental work the diaphragm has been found to be a less satisfactory method for measuring the transmitted pressures than the method of weighing the load on the plug.

The reason is that the diaphragm becomes distorted when load is applied, the center being depressed and the outside portion raised by the water pressure; and the distortion increases with the repetition of the load. So much trouble was experienced with the bursting of the diaphragm that it could not be used for off center loads or thin layers of sand.

For the relation between the intensity of pressure directly below the center of the loaded area to the applied average unit load, the following equation was found:

$$p = 91 \frac{d^{1.96}}{h^{1.96}}$$

in which p is the ratio expressed as per cent which the intensity of the transmitted pressure at a point h, 8 in. directly below the center of the loaded area bears to the average applied unit load, and d is the diameter of the plate in inches. This equation represents roughly the results of the experiments, and it is not probable that it has a general application.

Curves are given showing the intensity of the transmitted pressure at different distances from the center line of the applied load in terms of the applied average unit load, as determined by experiments in which the transmitted pressure was measured by the 4 in. plug. Another set of curves gives the results of experiments showing lines of equal vertical pressure in the sand below the plate. The region below the center of the load is one of high pressure, and the diagram shows the manner of the distribution of the vertical pressure at different depths and different distances from the axis of the load. Among other things, it is seen that the pressure in horizontal planes is far from uniform. (*Railway Review*, vol. 58, no. 4, p. 129, Jan. 22, 1916, 4 pp., 12 figs. *e.*)

Balancing of Rotating Machine Parts, E. Heidebroek

The problem of the proper balancing of rotating parts of machinery became all the more important with the increases in the speeds at which machine parts are operated.

In the simplest way this problem is presented in the case of disc shaped bodies of limited extension axially, since, when the center of gravity of the rotating body is located not on the axis of rotation but at a certain distance from it, it is usually possible to place an additional mass at such a distance on the opposite side of the axis of rotation as to effect a static balancing. To do this methods of determining the so-called static balance may be used, of which there are several. It must be, however, borne in mind that at least some of the processes of determining this static balancing are affected by the rolling resistance between the body and its supports which the article discusses in full.

In order to increase the sensitiveness of the process of determination of static balancing, the axis of the balanced body is placed on movable lineal supports, for example, on wheel rims having knife edge tires. Such wheels are supported so as to be easily rotatable, and since the rolling resistance on the periphery acts on the lineal support tangentially, it has, in reference to the center of the disc, a comparatively long lever arm and will make the disc rotate even if it is very small in itself. Fig. 4A shows the Lebert apparatus for the determination of static balance. This apparatus is so sensitive that it will show an eccentricity of the center of gravity as low as 0.07 mm.

A similar purpose may be served by the so-called pendulum apparatus of which several are shown in the article. In this the body is suspended free to exert pendular motions so that the center of gravity of the entire aggregate must finally take a place exactly under the point of suspension. So far no very precise tests of these apparatus are available and the author doubts their usefulness since they may be affected by a number of sources of error and in any case cannot be more precise than an ordinary pendular balance.

In the case of bodies rotating at comparatively high speeds as in steam turbines, turbo-pumps, blowers, and dynamos, static balance is entirely insufficient. In a disc the center of gravity of which is only 0.5 mm away from the axis of rotation, the centrifugal force which may be considered as acting on the center of gravity of the mass, creates a load on the shaft which equals the weight of the disc already at a speed of about 1500 r.p.m. Hence, the bending stresses of the shaft due to centrifugal force may under certain circumstances quite materially exceed that exerted under a stationary load. Periodically alternating bending stresses arise which may set up in the shaft undesirable oscillatory phenomena.

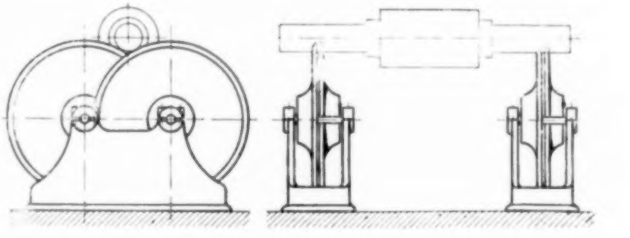
The distribution of mass forces becomes still more complicated when the body under consideration is not a disc but a drum-like structure, that is, with a considerable extension axially. In this case, it is impossible to obtain uniform running by means of purely static balancing only, since such purely static balancing does not take care of centrifugal forces which may be at any angle whatsoever to one another. Further, if such centrifugal forces be compounded they will always give a couple and a single force with the further complication that in nearly every case both the couple and the single force will lie in the plane of the axis of rotation, but the single force will not lie in the same plane as the couple. Fig. B gives an illustration of what would happen.

A couple Pl and a single force R are both of constant magnitudes as long as the speed of rotation remains the same. There is further a load G_0 due to gravity acting vertically downwards and a couple G_0x the magnitude of which periodically varies from zero to a positive and then a negative maximum. The axis of this last couple coincides with the axis of rotation, and the couple may, therefore, under certain conditions, produce periodic variations in the speed of rotation of the shaft. Even if this possibility be neglected, there still remains the problem which has to be taken care of in balancing and which is determined by the fact that the couple Pl as well as the free force R have to be eliminated entirely or reduced as much as possible, since both of them moving at the speed of rotation of the shaft, may impart to the shaft more or less powerful oscillatory impulses or vibration.

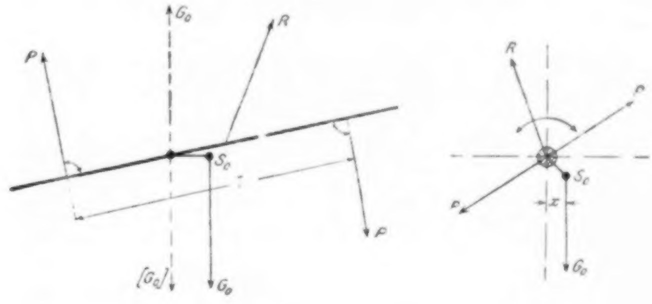
This consideration of the distribution of forces which affect every rotating body shows that static balancing alone can never be sufficient. The static balancing takes place in a state of rest when only forces of gravity are present and it helps only to establish the proper position of the resultant center of gravity but does not in the least eliminate the resultant couple and free force created by the action of the centrifugal forces. Here and there one can still find in technical literature intimations that by static means an amount of balancing sufficient for practical purposes may be obtained. This is entirely wrong since in rapidly rotating machine parts the couple and free force connected therewith and described above are of particular importance, as under certain conditions they may attain dangerous proportions. This may happen if they come into resonance with the natural period of vibration of the system affected, but even apart from the question of resonance these forces may produce injurious vibrations. The couple created by the centrifugal forces tends to jar the shaft in its bearings hither and thither which produces an overload and excessive wear of bearings.

A material improvement in the methods of determining the conditions of balancing of bodies is represented by the process suggested and patented some years ago by Dr. Lavaczeck. The essence of the apparatus consists in the utilization of the resonance action itself for the determination of the lack of balance. Instead of setting the shaft in bearings having freedom of pendular motion, Lavaczeck provides, as shown in Fig. C, two bearings, one of which has freedom of horizontal rotation, while the other is held by springs and has freedom of pendular action. Hence the entire system located in a horizontal plane acts simply as a physical pendulum in which the oscillation phenomena can be fairly easily established by calculation.

It is quite easy to bring the entire system into a state of resonance even at a slow speed of rotation by taking into consideration the stiffness of the spring, the distance between the bearings, the oscillating masses, etc. The drive is applied by a motor through a flexible shaft or belt, the motor being placed in the rear of the rotatable bearing. In order to increase as much as possible the sensitiveness of the apparatus, all bear-



A



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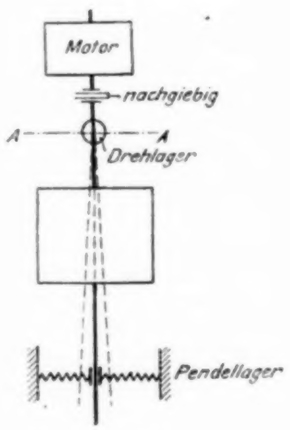

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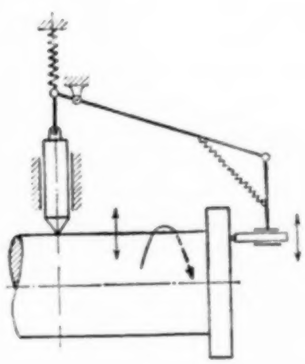

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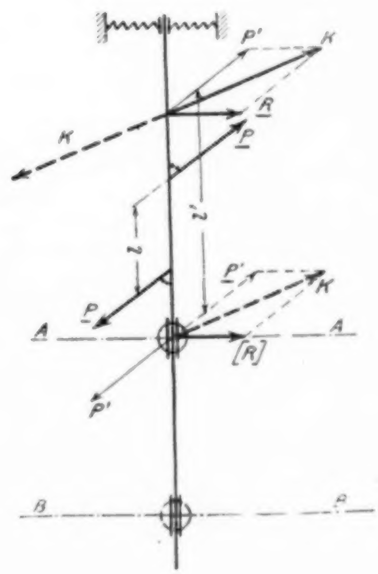

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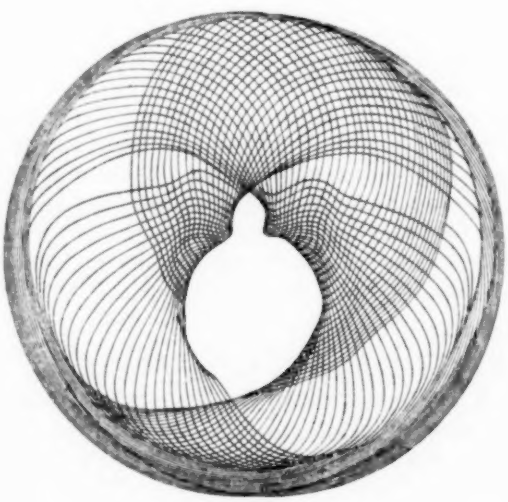

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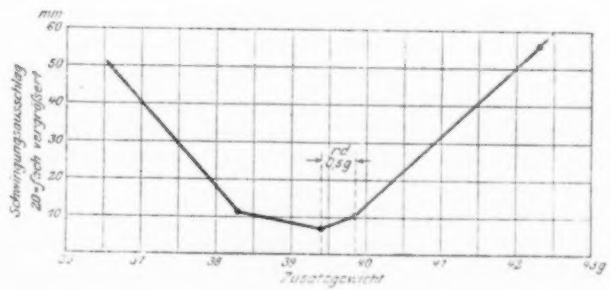

G

FIG. 4 BALANCING OF ROTATING MACHINE PARTS

A, Roller Apparatus for Static Balancing; B, General Diagram of Unbalanced Forces; C, Diagram of the Lavaczek Balancing Apparatus (*nachgiebig*, flexible; *Drehlager*, rotatable bearing; *Pendellager*, oscillating bearing); D, Recording Indicator of the "Zero of Unbalance"; E, Diagram Plotted with the Shaft Running in Both Directions, on the Front Side of the Shaft; F, Elimination of the Couple and Single Force by the Lavaczek Method; G, Sensitiveness of the Apparatus when the Weight of the Rotating Mass is about 100 kg (220 lb.): ordinates: amplitude of oscillations, magnified twenty times; abscissae: balance weights, in grams.

ings and journals are of ball bearing type and hence practically free from friction. In tests made it has been found that the damping of oscillations no matter how produced in the system itself, is extremely slight, in fact the apparatus has been found so sensitive that unbalancing weights as low as fractions of one gram show their presence quite noticeably by definite indications in the development of the state of resonance.

Of particular interest is Lavaczeck's process for the determination of the "plane of unbalance." The head of the oscillating shaft (Fig. D) carries a circular sheet of paper tightly held, on which slides a recording stylus operated from the oscillating shaft by a special indicating device. This is done by placing on the shaft a small piston actuated by a slight spring pressure. If now the shaft makes an oscillation, the piston transfers it, magnified, to the stylus which simultaneously records it on the piece of paper. Because of the simultaneous rotation of the recording disc slight oscillations appear as cavitations of the circular motion of the stylus with respect to the shaft. The greater the oscillations the sharper are the curvatures and if the maximum oscillation is allowed to reach the middle part of the sheet of paper, it is recorded as a clear angular peak.

If, therefore, the indicator be allowed to run over the paper for a certain period of time during resonance, the peaks recorded will show the "plane of unbalance" which (as is shown elsewhere in the article) must have a phase variation of about 90 deg. with respect to the maximum amplitude of oscillation. For safety's sake the shaft may be allowed to make one revolution forward and one revolution backward. If then a radial plane be passed through the peaks of the diagram thus obtained and the angle between the two be bisected, the bisectrix of the angle will directly indicate the "plane of unbalance" on the head of the shaft. Tests made in this connection have shown that the above described process permits of determining in a few minutes the location of the "plane of unbalance" with the precision of a few degrees. Fig. E shows such a diagram taken with the shaft running in both directions.

The Lavaczeck process permits also of eliminating both the couple Pl and the free single force R; compare diagram Fig. F. The couple Pl can be assumed to be replaced by another couple acting in the same plane $P'l'$ of which the force P' passes through the point of application of the free force R which the other force of the couple P' passes through the center of rotation of the shaft. The forces $P'R$ give together a resultant K which exerts a moment with respect to the center of rotation of the shaft and tends to set up oscillations in the shaft. The plane of this resultant can be easily found in the usual manner.

In order to equalize these oscillations all that has to be done is to produce in this plane another couple by the addition of weights such as to make the shaft run oscillation-free. This additional couple can be again assumed to be represented by a couple of the magnitude Kl' of which one of the forces passes through the center of rotation of the shaft while the other force opposes and eliminates the original force K. One can now imagine the force K, having its point of application in the center of rotation of the shaft, to be resolved into its original components P' and R. It is clear then that the two forces P' having their point of application in the center of rotation of the shaft mutually eliminate each other and only the force R remains at the center of rotation.

The result of this system of balancing is therefore the entire elimination of the couple and the transference of the single force to the center of rotation of the shaft. What remains now is to eliminate this single force. To do this one may either turn the shaft itself in its bearings so that the force R falls into the pendular bearing, or the center of rotation may be displaced from A to B so that the still available free force R should have a lever arm with respect to the center of rotation and would produce oscillations in the shaft. Then this single force can be balanced and its plane determined in the manner described above.

It appears therefore that this process permits of obtaining a theoretically perfect balancing. Comprehensive tests have been made on a machine with steel discs weighing about 50 kg. (110 lb.), each of which would balance singly and together. These discs had a diameter of about 600 mm (23.6 in.), a reinforced rim, and bore of about 60 mm (2.36 in.). Although they were very carefully machined, previous to balancing they produced quite violent oscillations, while after balancing it became quite possible to reduce to resonance the practically undamped oscillations of the pendular bearing of fractions of 1 mm, or to obtain a motion practically free from vibrations.

Fig. G shows how sensitive this process is. It indicates amplitudes of oscillations measured with various additional weights and shows that oscillating masses of 100 kg. (220 lb.) were affected in their motions by additions of weight of 0.5 grams (77.1 grains) while the total amplitude has a minimum of only 7/20 mm (0.0102 in.), which is all the more remarkable as such an amplitude is obtained at resonance. This play moreover is obtained with a fairly large bore of bearing and disappears entirely with the slightest damping. Since the additional weight is placed at a distance about 300 mm (11.81 in.) from the axis, a variation of weight of 0.5 grams (77.1 grains) with a total weight of 100 kg. (220 lb.) represents a displacement of the center of gravity of the mass of only 0.001 mm (0.000039 in.). Speed at resonance during the tests lay between 400 and 600 r.p.m. and by selecting a weaker spring this speed can be still further reduced, so that the handling of the apparatus requires neither exceptional care nor very large power consumption, such as is indispensable with the higher speeds.

The article describes and illustrates the actual construction of the Lavaczeck apparatus. It is of interest because, as the author states, a good balancing device of the dynamic type ought to be in use now-a-days in every mechanical shop side by side with other machine tools. (*Zeits. des Vereines deutscher Ingenieure*, vol. 60, nos. 1, 2, pp. 11 and 32, January 1 and 8, 1916, 8 pp., 25 figs. *ed.*)

Steam Engineering

Boiler Corrosion, John C. B. Kershaw

Discussion of the effects of dissolved salts in feed water upon boiler life and management.

The author emphasizes the point that salts which may be quite harmless in their action upon iron and steel at pressures and temperatures in general use for boilers operating 10 or 15 years ago, may undergo rapid chemical decomposition and become corrosive in their action at steam pressures of 180 to 225 lb., equivalent to temperatures of 372 to 392 deg. fahr. He states, therefore, that under modern conditions of boiler temperature and pressure, sodium chloride and possibly sodium sulphate in the presence of an alkali, do attack and corrode boiler plates and fittings.

Among other things the author gives several practical examples personally known to him of corrosion due to the presence of dissolved salts in feed water. In one case an excessively high content of dissolved salt matter was found in a boiler where the feed water contained comparatively little

chlorides and ordinary care was taken as regards blowing-off. Soda ash was indicated as the origin of the impurity and the test of a sample showed 49.5 per cent of sodium chloride and only 46.3 per cent of carbonate. This is proof of the need that exists for all engineers who use alkaline salts for softening purposes, of having them tested from time to time in order to see whether they contain cheap and dangerous adulterants like common salt.

In another case of corrosion, it was found that an excessively high content of dissolved salts was due to their accumulation in the boiler and to failure to blow off the boiler at sufficiently frequent intervals.

The author believes that the retention of the old two-and-a-half-thirty-seconds salinometer limit for sodium chloride or other dissolved salts given in English engineering pocket-books, is responsible for much of the trouble with land boilers and only the purest water should be allowed as feed water. The author expresses this in the formula: "To keep all soluble salts outside the boiler and to use for feed-water purposes water entirely free from dissolved gaseous and salt impurities." (*Cassier's Engineering Monthly*, vol. 48, no. 5, p. 271, November 1915, 6 pp. *p.*)

SOME POINTS ON WATER SOFTENING BY LIME AND SODA PROCESS, Frederick A. Anderson

Discussion of the problem of determining, when lime and soda processes are applied for the treatment of water, what quantities of reagents are required and whether the results are satisfactory. The article describes some valuable methods, not yet to be found in every text book, for the determination of free carbon dioxide, alkalinity, total lime and total magnesia. The author expresses alkalinity in "degrees,", one degree being the equivalent of one grain of calcium carbonate per gallon. (*Journal of the Society of Chemical Industry*, vol. 34, no. 23, p. 1180, December 15, 1915, 2 pp. *dp.*)

WATER OF CONDENSATION FROM STEAM TURBINES FOR BOILER FEEDING, M. R. Schulz

Further discussion on the question of maintenance of clean feed water in boilers, now with reference to the feeding of boilers by water of condensation from steam turbines. For an abstract of the preceding article see *The Journal*, July 1914, p. D149.

It is the general impression that the water of condensation from steam turbines is quite clean in itself and can cause no scale deposits in the boiler or corrosion of metal parts. The author strongly disagrees with this view.

He makes a distinction between rust and corrosion, defining *rust* as a uniform oxidation of the entire surface of a metal article (iron or steel), and *corrosion* as an intensive chemical process essentially local in its action. In the case of boilers fed by water of condensation from steam turbines one has to deal with a mixture of water of condensation proper and additional feed water more or less clean initially or cleaned in proper apparatus. While water of condensation from steam turbines greedily absorbs oxygen and air, oxygen alone will not produce any corrosion of iron, and it is the air that does it mainly.

The best way to eliminate air from water is to heat the latter to 80 or 90 deg. cent. (176 or 194 deg. fahr.) which would, however, entirely eliminate the function of cast iron preheaters. Recently an apparatus has been placed on the market in which air is eliminated from the feed water by driving the latter through a bed of iron shavings. The principle is in itself correct, but it seems that the apparatus has not yet been fully perfected, as its action ceases as soon as the filler material is consumed, besides which it has the further disadvantage that a part of the iron oxide produced by the chemical reactions to which the usefulness of the process is due, is carried over into the preheater and even into the boiler, and produces a dangerous foaming.

Another statement to which the author seriously objects is that water of condensation from steam turbines contains no oil. In the first place, through carelessness of attendants, especially on the low pressure side, a vacuum may be created causing oil to be sucked in from the bearings. Further, a certain amount of oil may penetrate into the feed water from the intermediary units such as feed water pumps, condenser pumps, etc., and the author states that he has found greater or less amounts of oil in the water of condensation in practically all the electric power stations which he has investigated. In fact, it is easy to notice such oil by observing the opalescent layer on the surface of the water of condensation in the collector tank, and the larger the surface of such a tank the easier the oil can be seen.

In this connection it must be borne in mind that the oil which flows on top in the tank is by no means all the oil that is contained in the water, since a large amount of it is suspended throughout the water in a state of emulsion.

Settling tanks are of little use in this connection unless they are extremely large, so large indeed, that the water may come freely to a state of rest. The so-called coke or gravel filters, even when built in several compartments, take up only that oil which comes into immediate contact with the filter material, while the rest of the oil flows freely over. The author believes, therefore, that there are only two reliable methods of oil separation and they are the electrolytic process and oil separation by chemical reactions, *e. g.*, the lime-soda process.

He firmly believes that in most cases where corrosion occurs, it is due in the first instance to the presence of oil in the feed water. There is, however, one other important source of corrosion, and that is the presence of impurities in the additional feed water. In some cases where complaints of corrosion were investigated, it was found that the cleaning apparatus for the additional feedwater was too small to take proper care of it. In this connection the author emphasizes an opinion expressed elsewhere both by him and other engineers, that it is not the air itself but the carbon dioxide that is the most dangerous agent of corrosion, and from this point of view he raises serious objections to the use of the so-called Permutit process. If day after day, 10 per cent of water treated by Permutit be added to the water of condensation from steam turbines, the percentage of carbon dioxide in the form of sodium carbonate will gradually increase in the boiler water. Now, sodium carbonate decomposes under the combined action of pressure and high temperature, and the interesting part of it is that corrosion coming from this source will affect steam piping, superheaters, etc., but not boilers (at least not to any large degree) since boilers are fed below the water level.

As regards using distilled water for feed-water purposes the author states that distilled water is essentially clean water but by no means "chemically pure," since there are several impurities such as carbon dioxide and ammonia which are not eliminated from the water either by the initial vaporization or by subsequent condensation. They not only stay in water but undergo a process of enrichment so that they produce practically the same phenomena of corrosion as when undistilled impure water is used. (*Ueber Verwendung von Dampftur-*

binenkondensat zum Speisen von Dampfkesseln, M. R. Schulz, Zeits. für Dampfkessel und Maschinenbetrieb, vol. 38, no. 51, p. 417, December 17, 1915, 3 pp., *p.*)

DRAFT GAGES ON OIL BURNING BOILERS, F. H. Rosencrants

Description of the right and wrong ways of connecting draft gages to oil burning boilers and the good and bad results which follow.

Some connections tolerated on coal burning installations because usually the front dampers are kept wide open and the fuel bed forms the major portion of the resistance to the gas passage, would be entirely inadequate for oil burning boilers, as there is an unlimited number of damper combinations that will admit the same amount of air to the furnace and several combinations will give a different draft reading. Hence the draft readings obtained when both front and back dampers are used for regulating the air supply are worthless. The writer recommends that either all regulating be done with the back damper, the front one always open the same amount, or that the gage be connected as in Fig. 5 A or B, as in either case the resistance offered to the flow of gases between the two points of connection of the gage is constant, and the draft will vary with the rate of gas flow. The fact that the draft resistance of oil burning boilers and other furnaces is small makes the air infiltration small, but the consequent small draft makes its indication difficult with existing gages with sufficient accuracy to be of value. It is important that the gage be checked frequently to be sure that it reads zero for zero draft, for which purpose it is advisable to install three way valves as shown in Fig. A. To increase draft readings it may sometimes help to change the combustion chamber connection down to the ashpit and thereby add the resistance of the furnace to the draft reading. Usually this will be a mistake because the aspirator action of the burner makes the furnace resistance negative and reduces the draft below that which will be shown when the gage is connected as indicated in Figs. A and B. The draft readings may be slightly increased by projecting the connection at the rear pass into the setting and putting an ell on the end of the pipe, turning its open end in the direction of the gas travel. (*Power*, vol. 43, no. 5, p. 147, February 1, 1916, 2 pp., 3 figs. *d.*)

EQUATIONS FOR AMMONIA BASED ON NEW EXPERIMENTAL MATERIAL, Fred. G. Keyes

Presentation of data from a series of exhaustive experiments on the thermal properties of ammonia, together with some equations and a discussion of previous work in this connection. The paper is based on work done at the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology, and covers the determination of the vapor pressure of the liquid to the critical point, the specific volume of the liquid to pressures of 1000 atmos. and to 200 deg. cent., the specific volumes of the vapor in the superheated region, and the specific heat capacity of the liquid; results are given mainly in tables.

In computing the results of experimental work of this nature many corrections must be applied before the final experimental values can be accepted. Allowance must be made for the temperature expansion of the steel ammonia container and the mercury used to confine the ammonia. The dilation of the experimental system itself, due to pressure, must be considered; likewise the various mercury and oil levels existing in the experimental system enter into the reduction of each pressure observation. The calibration data of the thermometers are in themselves a small investigation. In spite of all the pains taken, the data obtained are seldom as good as within 1/10 per cent of the true values.

It is expected that in the near future ammonia tables based on the new experimental data will be issued. The complete equation giving the pressure in atmospheres is as follows:

$$\log_{10} p = -\frac{1969.65}{T} + 13.31704 - 3.2385 \times 10^{-2}\, T$$
$$+ 5.4131 \times 10^{-5}\, T^2 - 3.2715 \times 10^{-8}\, T^3$$

It has been known that Regnault's high pressure or closed manometer readings were too low, and Mosher's investigation gave higher readings. Table 2 gives the pressures in atmospheres assigned by Regnault and those resulting from the

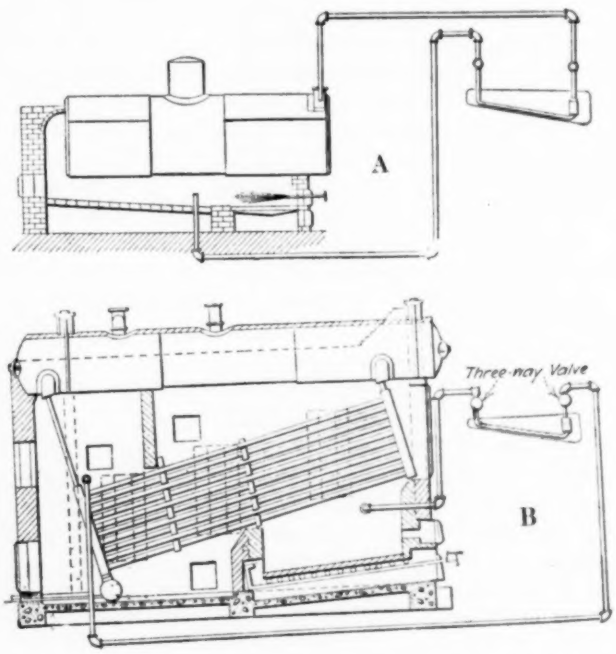

FIG. 5 PROPER CONNECTIONS OF DRAFT GAGES ON OIL-BURNING BOILERS

A, For Horizontal Tubular Boilers; B, For Water-Tube Boilers

new work for each 10 deg. cent. from — 30 to + 100 deg. Table 3 gives the new values of the saturation specific volume of liquid ammonia at each 20 deg. cent. from — 50 to + 120 deg., together with older values.

For the heat of evaporation of liquid ammonia, the following equation connecting heat of evaporation and temperature was obtained:

$$\log_{10} L = 1.56817 - 2.822 \times 10^{-5}\,(T_{-c} - T)$$
$$+ 0.43387 \log_{10}(T_{-c} - T)$$

where T_{-c} is the critical temperature. Table 4 gives the values of L, together with those values in the tables of Regnault, Jacobus, and Kraus.

For measuring heat capacities of liquid ammonia, the following method was used: A steel bomb containing liquid ammonia under the pressure of its saturated vapor is brought to a constant temperature in a thermostat above the calorimeter. It is then dropped into a calorimeter containing a definite weight of water, and the temperature change of the calorimeter is observed. Another steel bomb, identical with the first but containing water under the pressure of its saturated vapor, is placed in the thermostat and dropped into the calorimeter. The weight of water in the water bomb is adjusted by repeated experiments until it gives practically the same temperature change as the ammonia bomb. This

method is dependent for operation on a large temperature difference between the thermostat and the calorimeter, but the errors are the same, or nearly so, for both the ammonia and the water experiments, and are consequently compensated.

The equation taken to represent the saturation liquid specific heat capacity is somewhat arbitrary. It seems probable that because of the term dv/dT the heat capacity becomes infinite at the critical temperature. For this reason the empirical equation chosen to represent the heat capacity was

$$C_{s2}=1.13747-\frac{5.7575}{(T_c-T)}+\frac{898.53}{(T_c-T)}$$

and this equation passes through two measurements made in the course of this investigation. The equation for the integral heat referred to zero deg. cent. is

$$\int_{273.1}^{T} C_{s2}\,dT=1.13747T+13.257\log_{10}(T_c-T)+\frac{898.53}{T_c-T}-345.556$$

A table gives a list of values for the specific heat of liquid ammonia herein obtained.

In the discussion which followed the author stated that he is by no means convinced that all the so-called throttling phenomena are in reality Joule-Thomson experiments. Joule made a large number of observations which imitated very closely the so-called throttling. He found that only under very particular conditions could he obtain numbers which coincided with the meaning expressed by the equation:

$$\left(\frac{dT}{dp}\right)=\frac{T\left(\frac{\delta U}{\delta T}\right)_p-U}{C_p}$$

The truth of the matter probably is that the reduction in the temperature produced by the expansion of a liquid through an orifice is, so to speak, a mixture of this latter equation and

$$\left(\frac{dT}{dp}\right)=\frac{T\left(\frac{\delta U}{\delta T}\right)_p}{C_p}$$

but further investigation is necessary to determine whether in the so-called expansion valve a Joule-Thomson phenomenon really takes place. (*A.S.R.E. Journal*, vol. 2 no. 4, p. 20, January 1916, 19 pp., 5 figs. *et A.*)

TABLE 2 VAPOR PRESSURES OF LIQUID AMMONIA IN ATMOSPHERES

Temp. °C.	Regnault	New Values
−30	1.140	1.177
−20	1.831	1.885
−10	2.821	2.892
0	4.189	4.278
10	6.018	6.127
20	8.402	8.535
30	11.45	11.60
40	15.26	15.44
50	19.95	20.16
60	25.62	25.90
70	32.47	32.78
80	40.59	40.95
90	50.16	50.56
100	61.36	61.83

TABLE 3 SPECIFIC VOLUME OF LIQUID AMMONIA AT SATURATION POINT IN CC. PER GRAM

Temp. °C.	Lange	Dieterici	Mosher	Brownlee and Keyes
−50	1.4375	......	1.4351	1.4222
−30	1.4895	......	1.4851	1.4742
−10	1.5480	......	1.5415	1.5330
0	1.5795	1.5656	1.5728	1.5656
20	1.6503	1.6342	1.6430	1.6387
40	1.7383	1.7227	1.7268	1.7255
60	1.8487	1.8250	1.8307	1.8328
80	1.9982	1.9595	1.9675	1.9757
100	......	2.1525	2.1684	2.1859
120	......	......	2.5538	2.5965

TABLE 4 COMPARISON OF LATENT HEATS. CAL. PER KG.

Temp. °C.	Calculated by Equation (3)	Observed	Percentage Difference	
−33.4	336.7	321.3	−4.58	Estreicher & Schuerr.
−33.2	336.5	336.6	+ .03	Franklin & Kraus measured.
−33.2	336.5	336.8	+ .08	Franklin & Kraus from ebullioscopic constant.
−23.71	328.1	316.1	−3.6	Regnault—Jacobus—Denton.
−19.55	324.5	335.1	+3.2	Regnault—Jacobus—Denton.
− 9.72	316.0	317.0	+ .3	Regnault—Jacobus—Denton.
7.80	298.4	293.0	−1.8	Regnault—Jacobus.

CHARTS

FEED WATER TEMPERATURE, "ECONOMIZER EQUATION," Albert W. Smith. *The Sibley Journal of Engineering*, vol. 30, no. 4, January 1916.

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CHART FOR FINDING REQUIRED FEED-WATER HEATING SURFACE, ECONOMIC LIMIT OF FEED-WATER HEATING SURFACE, F. H. Rosencrants, *Power*, vol. 43, no. 4, January 25, 1916.

DIAGRAM FOR COMPRESSION AND EXPANSION OF AIR, AIR IN COMPRESSION AND EXPANSION, C. K. Bennett, *Power*, vol. 43, no. 6, February 8, 1916.

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